KEYS TO SOIL TAXONOMY

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ARIDISOLS
ENTISOLS
HISTOSOLS
INCEPTISOLS
MOLLISOLS
OXISOLS
SPODOSOLS
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SOIL FAMILY

United States
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Soil Management Support Services

Technical Monograph No. 6.

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SMSS
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KEYS TO SOIL TAXONOMY

Prepared by
Agronomy Department
Cornell University
Ithaca, New York

For

THE SOIL MANAGEMENT SUPPORT SERVICES

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1983

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Foreword

This publication, "Keys to Soil Taxonomy", serves two purposes. It provides the taxonomic keys required for the classification of a soil in a form that can be used easily in the field, and it serves as a means of providing an up-to-date edition of *Soil Taxonomy* that includes all revisions that have been approved. It replaces the keys in Soil Taxonomy, but it does not replace Agriculture Handbook 436, which contains descriptive material, laboratory data, and chapters on other subjects related to Soil Taxonomy. We plan to keep "Keys to Soil Taxonomy" up-to-date as a working tool and reprint the text on a regular basis. Agriculture Handbook 436 will be revised and reissued in the future after substantial revisions have been made. We will continue to make it available for purchase from the United States Government Printing Office. This publication incorporates amendments that were published in National Soil Taxonomy Handbook Issues No. 1 and No. 2 dated March 1975 and July 1982 respectively. Much of the explanatory text of the 1975 edition has been eliminated to facilitate the use of the keys in the field. The keys reproduced here were printed from a computer tape of the text of *Soil Taxonomy*, which was stored in its original form so that future revisions can be made with a minimum of manual revision and editing. We hope that by making updated issues of this publication available on a recurring basis we can help to keep Soil Taxonomy a dynamic classification system. This relatively inexpensive method of revision and reproduction will permit more frequent introduction of new concepts into the system.

We wish to acknowledge the contributions of Dr. Terence Forbes of the Agronomy Department, Cornell University, and Evelyn Robertson of the Integrated Resources Information Staff, Soil Conservation Service. Dr. Forbes managed the computer storage of *Soil Taxonomy* and the production of this book. Mrs. Robertson helped to make the computer programs compatible with data processing equipment used by the Soil Conservation Service.

RICHARD W. ARNOLD 1983
Director, Soils
Soil Conservation Service

Chapter 1
Horizons and Properties Diagnostic for the Higher Categories: Mineral Soils

Mineral soil material

Mineral soil material either

1. Is never saturated with water for more than a few days and has <20 percent organic carbon by weight; or

2. Is saturated with water for long periods or has been artificially drained, and has

- **a.** Less than 18 percent organic carbon by weight if 60 percent or more of the mineral fraction is clay;
- **b.** Less than 12 percent organic carbon by weight if the mineral fraction has no clay; or
- **c.** A proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent.

Soil material that has more organic carbon than the amounts just given is considered to be organic material.

Definition of mineral soils

Mineral soils, in this taxonomy, are soils that meet one of the following requirements:

1. Mineral soil material <2 mm in diameter (the fine-earth fraction) makes up more than half the thickness of the upper 80 cm (31 in.);

2. The depth to bedrock is <40 cm and the layer or layers of mineral soil directly above the rock either are 10 cm or more thick or have half or more of the thickness of the overlying organic soil material; or

3. The depth to bedrock is ≥40 cm, the mineral soil material immediately above the bedrock is 10 cm or more thick, and either

- **a.** Organic soil material is <40 cm thick and is decomposed (consisting of hemic or sapric materials as defined later) or has a bulk density of 0.1 or more; or
- **b.** Organic soil material is <60 cm thick and either is undecomposed sphagnum or moss fibers or has a bulk density that is <0.1.

Buried soils

A soil is considered to be a buried soil if there is a surface mantle of new material that is 50 cm or more thick or if there is a surface mantle between 30 and 50 cm thick and the thickness of the mantle is at least half that of the named diagnostic horizons that are preserved in the buried soil. A mantle that is <30 cm thick is not considered in the taxonomy but, if important to the use of the soil, is considered in establishing a phase. The soil that we classify in places where a mantle is present, therefore, has its upper

boundary at the surface or <50 cm below the surface, depending on the thickness of its horizons.

A surface mantle of new material as defined here is largely unaltered. It is usually finely stratified and overlies a horizon sequence that can be clearly identified as the solum of a buried soil in at least part of the pedon, as defined in the following chapter. The recognition of a surface mantle should not be based solely on studies of associated soils.

Diagnostic surface horizons; the epipedon

Six diagnostic horizons that form at the surface are defined. Any horizon, however, may be at the surface of a truncated soil. A horizon that forms at the surface is called an epipedon (Gr. *epi,* over or upon, and *pedon,* soil). The epipedon not only has formed at the surface but it also has been either appreciably darkened by organic matter or eluviated or, as a minimum, rock structure has been destroyed. Such a horizon may become covered by thin deposits of fresh alluvium or by thin eolian deposits without losing its identity as an epipedon. The depth to which an epipedon must be buried to be considered part of a buried soil is defined below. Generally a buried horizon lies below a depth of 50 cm or more, usually more.

There can be only one epipedon formed in the mineral surface horizon(s) of a soil. This epipedon may be overlain by organic materials that may meet the definition of a histic epipedon (defined later). Otherwise one soil may contain only one epipedon.

A recent alluvial or eolian deposit that retains fine stratifications or an Ap horizon that is directly underlain by material that retains fine stratifications are not included in the concept of the epipedon because time has not been sufficient for soil-forming processes to erase these transient marks of deposition and for diagnostic and accessory properties to develop.

The epipedon is not a synonym for the A horizon because it may include part or all of the illuvial B horizon if the darkening by organic matter extends from the surface into or through the B horizon.

To avoid changes in classification of a soil as the result of plowing, the properties of the epipedon, except for structure, should be determined after the surface soil to a depth of 18 cm has been mixed or, if the depth to bedrock is <18 cm, after the whole soil down to rock has been mixed.

Mollic epipedon (L. *mollis,* soft)

Properties

The mollic epipedon is defined in terms of its morphology rather than its genesis. It consists of mineral soil material. It is a surface horizon or horizons unless (a) it underlies a recent deposit that is <50 cm thick and that has fine strati-

fications if not plowed or (b) it underlies a thin layer of organic material in a wet soil (see histic epipedon). If the layer of organic material is thick enough that the soil is organic, the mineral soil is considered to be buried.

The mollic epipedon has the following properties:

1. Soil structure is strong enough that the major part of the horizon is not both massive and hard, or very hard when dry. Very coarse prisms, >30 cm in diameter, are included in the meaning of massive if there is no secondary structure within the prisms.

2. Unless there is >40 percent finely divided lime, both broken and crushed samples have Munsell color value darker than 3.5 when moist and 5.5 when dry, and chroma less than 3.5 when moist;[1] the color value normally is at least 1 Munsell unit darker or the chroma is at least 2 units less (both moist and dry) than that of the IC horizon if an IC horizon is present. If only a IIC horizon or an R layer is present, the comparison should be made with the horizon that overlies the IIC. Some parent materials such as loess, cinders, alluvium, or carbonaceous shales also can have dark color and low chroma. Soils formed in such materials may accumulate appreciable amounts of organic matter but have no visible darkening in the epipedon. In this situation, the requirement that the mollic epipedon have lower value or chroma than the IC horizon, or than the next underlying horizon if there is no IC, is waived if (a) the surface horizon (horizons) meets all other requirements for a mollic epipedon and, in addition, has at least 0.6 percent more organic carbon than the IC or the IIC horizon or if (b) the epipedon extends to rock (either a lithic or paralithic contact as defined later).

The mollic epipedon is expected to have dark color and low chroma throughout the major part of its matrix. If the structure is fine granular or fine blocky, the color when broken may be only the color of the coatings. The color of the matrix in such situations can be determined only by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-manganese concretions are present; crushing should be only enough to break and mix the coatings. The color value when dry should be determined after the crushed sample has been smoothed to eliminate shadows.

If there is >40 percent finely divided lime, the limits of color value, dry, are waived; the color value, moist, then should be 5 or less. This waiver is necessary because finely divided lime acts as a white pigment.

3. Base saturation is 50 percent or more by the NH_4OAc method.

4. The organic-carbon content is 2.5 percent or more in the upper 18 cm if the color requirement is waived because of finely divided lime. Otherwise, the organic-carbon content is at least 0.6 percent (1 percent organic matter) throughout the thickness of soil specified in item 5.

The mollic epipedon consists of mineral rather than organic soil material. Its organic-carbon content, therefore,

has an upper as well as a lower limit. The upper limit of organic carbon in a mollic epipedon is the same as that of mineral soil material; in part it is the lower limit for the histic epipedon, defined later in this chapter. Because an organic horizon can form above a mollic epipedon in a wet soil, the mollic epipedon is not necessarily the surface horizon but is the uppermost horizon composed of mineral soil material.

5. The thickness is one of the following after mixing the upper 18 cm of soil or the whole soil if the depth to rock, petrocalcic horizon, or duripan is <18 cm:

a. Ten cm or more if the epipedon is underlain directly by a lithic contact; 10 cm or more in soils of shallow families in which the epipedon is underlain directly by a paralithic contact, a petrocalcic horizon, or a duripan, all defined later in this chapter;

b. In other soils the epipedon must be >25 cm thick if its texture is finer than loamy fine sand and

(1) The upper boundary of pedogenic lime that is present as filaments, soft coatings, or soft nodules is deeper than 75 cm;

(2) The base of any argillic, natric, spodic, cambic, or oxic horizon is deeper than 75 cm; and

(3) The upper boundary of any petrocalcic horizon, fragipan, or duripan is deeper than 75 cm;

c. In other soils that have a loamy or clayey epipedon, the thickness of the epipedon must be 18 cm or more and it must be more than one-third of the depth from the top of the epipedon to the shallowest of one of the features listed in (b) if that is <75 cm;

d. In other soils the epipedon must be >25 cm thick if

(1) The texture of the epipedon is as coarse as or coarser than loamy fine sand throughout its thickness or

(2) If there are no underlying diagnostic horizons and the organic carbon content of the underlying materials decreases irregularly with increasing depth (as in recent alluvium that is not finely stratified); or

e. In other soils, the epipedon must be 18 cm (7 in.) or more thick if none of the conditions that are listed in *b, c,* and *d* exist.

6. The epipedon has <250 parts per million (ppm) of P_2O_5 soluble in 1 percent citric acid or it either has increasing amounts of P_2O_5 soluble in citric acid below the epipedon or the amounts of P_2O_5 soluble in citric acid decrease or increase irregularly with depth below the epipedon, or there are phosphate nodules within the epipedon. This restriction is made to eliminate plow layers of very old arable soils and kitchen middens that have acquired, under use, the properties of the mollic epipedon but to include the epipedon of a soil developed in highly phosphatic parent material.

7. If the soil is not irrigated, some part of the epipedon is moist 3 months or more of the year (cumulative) in more

than 7 out of 10 years at times when the soil temperature at a depth of 50 cm is 5°C or higher.
8. The *n* value (defined later in this chapter) is <0.7. Although many soils that have a mollic epipedon are very poorly drained, a mollic epipedon does not have the very high water content of sediments that have been continuously under water since deposition.

Anthropic epipedon

In summary, the anthropic epipedon conforms to all the requirements of the mollic epipedon except (1) the limits on acid-soluble P_2O_5, with or without the base saturation, or (2) the length of the period during which it has available moisture. Additional data on anthropic epipedons from several parts of the world may permit improvements in this definition.

Umbric epipedon (L. *umbra,* shade, hence dark)

Requirements of the umbric epipedon are comparable to those of the mollic epipedon in color, organic-carbon and phosphorus content, consistence, structure, *n* value, and thickness. The umbric epipedon includes those thick, dark-colored surface horizons, that have base saturation of <50 percent (by NH_4OAc). It should be noted that the restriction against a hard or very hard and massive epipedon when dry is applied only to those epipedons that become dry. If the epipedon is always moist, there is no restriction on its consistence or structure when dry. It should also be noted that some plaggen epipedons, defined later, meet all these requirements but also have evidences of slow addition of materials under cultivation. The umbric epipedon does not have the artifacts, spade marks, and raised surfaces that are evidences of slow additions in the plaggen epipedon.

Histic epipedon (Gr. *histos,* tissue)

The histic epipedon normally is at the surface, although it may be buried at a shallow depth. It normally is a thin horizon of peat or muck if the soil has not been plowed. If the soil has been plowed, the histic epipedon has the very high content of organic matter that results from mixing peat with some mineral material. Since peaty deposits occur in wet places, the histic epipedon either is saturated with water for 30 consecutive days or more during the year or has been artificially drained.

The histic epipedon, therefore, can be defined as a layer (one horizon or more) at or near the surface that is saturated with water for 30 consecutive days or more at some time in most years, or is artificially drained, and that meets one of the following requirements:
1. The surface horizon consists of organic soil material that either

a. Is 75 percent or more, by volume, sphagnum fibers

or has a bulk density, when moist, <0.1 and is <60 cm (24 in.) but >20 cm thick; or

b. Is <40 cm but >20 cm thick and meets one of the following requirements with respect to organic-carbon content and thickness:

(1) Has 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay;

(2) Has 12 percent or more organic carbon if the mineral fraction has no clay;

(3) Has an intermediate proportional content of organic carbon if part but less than 60 percent of the mineral fraction is clay.

2. The plow layer is 25 cm or more thick and has 8 percent or more organic carbon if it has no clay, or 16 percent or more organic carbon if 60 percent or more of the mineral fraction is clay, or an intermediate proportional content of organic carbon if part but less than 60 percent of the mineral fraction is clay.

3. A layer of organic material that has enough organic carbon and is thick enough to satisfy one of the requirements under item 1 lies beneath a surface layer of mineral materials that is <40 cm (16 in.) thick. In such a soil, the histic epipedon has been buried but the mineral materials at the surface are too thin to be considered diagnostic in the classification.

4. A surface layer of organic material <25 cm thick that has enough organic carbon to satisfy the minimum requirements under item 2 after the soil has been mixed to a depth of 25 cm.

Plaggen epipedon (Ger. *plaggen,* sod)

The plaggen epipedon is a manmade surface layer 50 cm (20 in.) or more thick that has been produced by long-continued manuring.

The color of a plaggen epipedon and its organic-carbon content depend on sources of the materials used for bedding.

The plaggen epipedon can be identified by several means. Commonly it contains artifacts, such as bits of brick and pottery, throughout its depth. Chunks of diverse materials, such as black sand and light gray sand, as large as the size held by a spade may be present. The plaggen epipedon normally shows spade marks throughout its depth and also remnants of thin stratified beds of sand that probably were produced on the surface by beating rains and later were buried by spading.

Ochric epipedon (Gr. *ochros,* pale)

An ochric epipedon is one that is too high in value or chroma, is too dry, has too little organic matter, has an *n* value too high, or is too thin to be mollic, umbric, anthropic, plaggen or histic, or it is both hard and massive when dry. An epipedon is ochric if the Munsell color value after rubbing is 5.5 or higher when dry or 3.5 or higher

when moist, if the chroma is 3.5 or more[2], or if the A1 or Ap horizon that has both low value and low chroma is too thin to be a mollic or an umbric epipedon. Epipedons that have a color value after rubbing lower than 5.5, dry, and lower than 3.5, moist, are also ochric provided they are no darker than the IC horizon and do not have as much as 0.6 percent more organic carbon than the IC horizon. The ochric epipedon includes some spodic horizons and eluvial horizons that are at or near the surface (the A2 horizon and an albic horizon, which is defined later) and extends to the first underlying diagnostic illuvial horizon (defined later as an argillic, natric, or spodic horizon). If the underlying horizon is a B horizon of alteration (defined later as a cambic or oxic horizon) and there is no surface horizon that is appreciably darkened by humus, the most convenient lower limit of the ochric epipedon is the base of the plow layer or an equivalent depth in a soil that has not been plowed. Actually, the same subhorizon in an unplowed soil may be both a part of the epipedon and a part of the cambic horizon. The epipedon and the subsurface diagnostic horizons are not mutually exclusive. The ochric epipedon does not have rock structure. It does not include fresh sediments that are finely stratified.

Diagnostic subsurface horizons

The horizons discussed in this section form below the surface of the soil, although in some places they form immediately below a layer of leaf litter. They may be exposed at the surface by truncation of the soil. Some of these horizons are generally considered to be B horizons; some are considered B horizons by many but not all pedologists; others are generally considered to be parts of the A horizon.

Argillic horizon

Summary of properties

In summary, we can say that an argillic horizon is one that contains illuvial layer-lattice clays. This horizon forms below an eluvial horizon, but it may be at the surface if a soil has been partially truncated. It has the following properties that can be used for identification:

1. If an eluvial horizon remains and if there is no lithologic discontinuity between it and the argillic horizon, the argillic horizon contains more total clay and more fine clay than the eluvial horizon, as follows. The increases in clay are reached within a vertical distance of 30 cm or less.

a. If any part of the eluvial horizon has <15 percent total clay in the fine-earth fraction (<2 mm), the argillic horizon must contain at least 3 percent more clay (13 percent versus 10 percent, for example). The ratio of fine clay to total clay normally is greater in the argillic horizon than in the overlying eluvial horizons or the underlying horizon by about one-third or more.

b. If the eluvial horizon has >15 percent and <40 percent total clay in the fine-earth fraction, the ratio of clay in the argillic horizon to that in the eluvial horizon must be 1.2 or more. The ratio of fine clay to total clay in the argillic horizon is normally greater than in the eluvial horizon by about one-third or more.

c. If the eluvial horizon has >40 percent total clay in the fine-earth fraction, the argillic horizon must contain at least 8 percent more clay or, if the total clay content exceeds 60 percent, 8 percent more fine clay (50 percent versus 42 percent, for example).

2. An argillic horizon should be at least one-tenth as thick as the sum of the thickness of all overlying horizons, or it should be 15 cm or more thick if the eluvial and illuvial horizons together are more than 1.5 m thick. If the argillic horizon is sand or loamy sand, it should be at least 15 cm thick. If it is composed entirely of lamellae, lamellae ≥1 cm thick should have a combined thickness of at least 15 cm. If the argillic horizon is loamy or clayey, it should be at least 7.5 cm thick.

3. In structureless soils, the argillic horizon has oriented clay bridging the sand grains and also in some pores.

4. If peds are present, an argillic horizon should meet one of the following requirements:

a. Have clay skins on some or both the vertical and horizontal ped surfaces and in the fine pores or have oriented clay in 1 percent or more of the cross section;

b. Meet requirements 1 and 2 and also have a broken or irregular upper boundary and some clay skins in the lowest part of the horizon;

c. If the horizon is clayey, if the clay is kaolinitic, and if the surface horizon has >40 percent clay, have some clay skins on peds and in pores in the lower part of the horizon that has blocky or prismatic structure; or

d. If the illuvial horizon is clayey with 2-to-1 lattice clays, an argillic horizon does not need to have clay skins if there are uncoated grains of sand or silt in the overlying horizon and evidences of pressure caused by swelling or if the ratio of fine to total clay in the horizon is greater by at least one-third than the ratio in the overlying or the underlying horizon or if it has >8 percent more fine clay. The evidences of pressure may be occasional slickensides or wavy horizon boundaries in the illuvial horizon.

5. If a soil has a lithologic discontinuity between the eluvial horizon and the argillic horizon or if only a plow layer overlies the argillic horizon, the argillic horizon needs to have clay skins in only some part, either in some fine pores or, if peds exist, on some vertical and horizontal ped surfaces. Either thin sections should show that some part of the horizon has about 1 percent or more of oriented clay bodies or the ratio of fine clay to total clay should be greater than in the overlying or the underlying horizon.

Agric horizon

The agric horizon (L. *ager,* field) is an illuvial horizon formed under cultivation that contains significant amounts of illuvial silt, clay, and humus. After long-continued cultivation, changes in the horizon immediately below the plow layer become apparent and cannot be ignored in classifying the soil. The worm channels, root channels, or ped surfaces become coated with a dark-colored mixture of organic matter, silt, and clay. The accumulation on the sides of wormholes becomes thick and eventually can fill them. If worms are scarce, the accumulation may take the form of thick lamellae that may range in thickness from a few millimeters to about 1 cm. The coatings on the sides of wormholes and lamellae always have lower color value and chroma than the soil matrix.

The agric horizon has somewhat different forms in different climates if there are differences in soil fauna. In a humid temperate climate, where soils have what is later defined as a udic moisture regime and a mesic temperature regime, earthworms can become abundant. If there are earthworm holes that, with their coatings, constitute 5 percent or more of the volume and if the coatings are 2 mm or more thick and have color value of 4 or less and chroma of 2 or less, moist, the horizon is considered an agric horizon. After long continued cultivation, the content of organic matter is not likely to be high, but the carbon-nitrogen ratio in the agric horizon is low, usually <8. The pH of the agric horizon is close to neutrality, 6 to 6.5.

In a Mediterranean climate, where soils have what is later defined as a xeric soil moisture regime, earthworms are less common and the illuvial materials accumulate as lamellae directly below the Ap horizon. If the lamellae are 5 mm or more thick, have color value of 4 or less, moist, and chroma of 2 or less, and constitute 5 percent or more by volume of a horizon that is 10 cm or more thick, the horizon is considered an agric horizon.

Natric horizon

The natric horizon (NL. *natrium,* sodium; implying presence of sodium) is a special kind of argillic horizon. It has, in addition to the properties of the argillic horizon:

1. Either

a. Prisms or, more commonly, columns in some part, usually the upper part, that may or may not break to blocks; or

b. Rarely, blocky structure and tongues of an eluvial horizon, in which there are uncoated silt or sand grains, extending more than 2.5 cm into the horizon; and

2. Either

a. The SAR[3] is ≥ 13 (or 15 percent or more saturation with exchangeable sodium) in some subhorizon within 40 cm of the upper boundary; or

b. More exchangeable magnesium plus sodium than calcium plus exchange acidity (at pH 8.2) in some

subhorizon within 40 cm of the upper boundary if the SAR is ≥ 13 (or ESP ≥ 15) in some horizon within 2 m of the surface.

Sombric horizon

The sombric horizon is a subsurface horizon of mineral soils formed under free drainage. It contains illuvial humus that is neither associated with aluminum, as is the humus in the spodic horizon, nor dispersed by sodium, as is common in the natric horizon. Consequently, the sombric horizon does not have the high cation exchange capacity of a spodic horizon relative to clay, and it does not have the high base saturation of a natric horizon. The sombric horizon does not underlie an albic horizon.

Sombric horizons are thought to be restricted to the cool moist soils of the high plateaus and mountains in tropical or subtropical regions. Because of the annual leaching, base saturation is low, <50 percent by NH_4OAc.

The sombric horizon has lower color value or chroma, or both, than the overlying horizon and commonly, but not necessarily, contains more organic matter than the overlying horizon. It may have formed in an argillic, a cambic, or, possibly, an oxic horizon. If peds are present, the dark colors are most pronounced on ped surfaces.

A sombric horizon is easily confused in the field with a buried A1 horizon. It can be distinguished from some buried epipedons by lateral tracing. In thin sections, the organic matter of a sombric horizon appears more concentrated on peds and in pores than uniformly dispersed through the matrix.

Spodic horizon

Summary of the limits of a spodic horizon

A spodic horizon is normally a subsurface horizon that underlies an O, A1, Ap, or A2 horizon. It may, however, meet the definition of an ochric or umbric epipedon. A spodic horizon has the morphological or the chemical and physical characteristics that are listed next, and its hue and chroma remain constant with increasing depth or the subhorizon that has the reddest hue or the highest chroma is near the top of the horizon. The color changes within 50 cm from the top of the horizon.[4] If the soil temperature regime is frigid or warmer, some part of the spodic horizon must meet one or more of the following requirements below a depth of 12.5 cm or below any Ap horizon that is present. If the soil temperature regime is cryic or pergelic, there is no requirement for depth. In addition, the spodic horizon must meet one or more of the following requirements:

1. Have a subhorizon >2.5 cm thick that is continuously cemented by some combination of organic matter with iron or aluminum or with both;

2. Have a particle-size class that is sandy or coarse-loamy, and sand grains are covered with cracked coatings or there

are distinct dark pellets of coarse-silt size or larger, or both; or

3. Have one or more subhorizons in which
   a. If there is 0.1 percent or more extractable iron, the ratio of iron plus aluminum (elemental) extractable by pyrophosphate at pH 10 to percentage of clay is $\geq$0.2 (percentage of pyrophosphate-extractable Fe + Al at pH 10/clay percentage $\geq$0.2) or if there is <0.1 percent extractable iron, the ratio of aluminum plus carbon extractable by pyrophosphate at pH 10 to percentage clay is $\geq$0.2 (percentage of pyrophosphate-extractable Al + C/clay percentage $\geq$0.2); and
   b. The sum of pyrophosphate-extractable iron plus aluminum is half or more of the sum of dithionite-citrate extractable iron plus aluminum (percentage of pyrophosphate-extractable Fe + Al/percentage of dithionite-citrate extractable Fe + Al $\geq$0.5); and
   c. The combined index of accumulation of amorphous material must be 65 or more. The index for each subhorizon is calculated by subtracting half of the clay percentage from CEC at pH 8.2 and multiplying the remainder by the thickness of the subhorizon in centimeters. The results for all subhorizons are then added and the total must be 65 or more.

Placic horizon

The placic horizon (Gr. base of *plax,* flat stone; meaning a thin cemented pan) is a thin, black to dark reddish pan cemented by iron, by iron and manganese, or by an iron-organic matter complex. Its thickness ranges generally from 2 mm to 10 mm. Rarely, it is as thin as 1 mm or as thick as 20 to 40 mm in spots. It may be, but not necessarily, associated with stratification in parent materials. It is in the solum, roughly parallel to the soil surface, and is commonly within the upper 50 cm of the mineral soil. It has a pronounced wavy or even convolute form. It normally occurs as a single pan, not as multiple sheets one underlying another, but in places it may be bifurcated. It is a barrier to water and roots.

An iron-cemented pan is strong brown to dark reddish brown. A pan cemented by iron and manganese or by iron-organic matter complexes is black or reddish black. A single pan may contain two or more layers cemented by different agents. Iron-organic matter cements commonly are present in the upper part of the pan.

Identification is seldom difficult. The hard brittle pan differs so much from the material in which it occurs and is so close to the surface of the mineral soil material that it is obvious unless its thickness is minimal. A few analyses of placic horizons show that organic carbon is present in amounts ranging from 1 percent to 10 percent or more. The presence of organic carbon as well as the shape and position of the pan distinguish the placic horizon from the ironstone sheet that may form where water hangs or moves laterally at a lithologic discontinuity.

Cambic horizon

Summary of properties

In summary, the cambic horizon is an altered horizon that does not have the dark color, organic-matter content, and structure that are definitive of a histic, a mollic, or an umbric epipedon, and it has

1. Texture that is very fine sand, loamy very fine sand, or finer in the fine-earth (<2 mm) fraction;

2. Soil structure or absence of rock structure in at least half the volume;

3. Significant amounts of weatherable minerals that consist of (a) enough amorphous or 2:1 lattice clay to give a cation-exchange capacity (by NH_4OAc) of more than 16 meq per 100 g clay, or (b) >3 percent weatherable minerals other than muscovite, or (c) >6 percent muscovite;

4. Evidence of alteration in one of the following forms:

- **a.** Gray colors as defined for an aquic moisture regime, defined later, or artificial drainage, and one or more of the following properties:
  - (1) A regular decrease in the amount of organic carbon with depth and a content of <0.2 percent organic carbon at a depth of 1.25 m below the surface or immediately above a sandy-skeletal substratum that is at a depth of <1.25 m;
  - (2) Cracks that open and close in most years and are 1 cm or more wide at a depth 50 cm below the surface;
  - (3) Permafrost at some depth;
  - (4) A histic epipedon consisting of mineral soil materials or a mollic or umbric epipedon;
- **b.** Stronger chroma, redder hue, or higher clay content than the underlying horizon;
- **c.** Evidences of removal of carbonates. Particularly, the cambic horizon has less carbonate than the underlying ca horizon. If all coarse fragments in the ca horizon are completely coated with lime, some in the cambic horizon are partly free of coatings. If coarse fragments in the ca horizon are coated only on the under side, those in the cambic horizon should be free of coatings;
- **d.** If carbonates are absent in the parent material and in the dust that falls on the soil, the required evidence of alteration is satisfied by the presence of soil structure and the absence of rock structure if the moisture regime is not aquic or the chroma is higher than those listed;

5. Properties that do not meet the requirements of an argillic or a spodic horizon;

6. No cementation or induration and no brittle consistence when moist; and

7. Enough thickness that its base is at least 25 cm (10 in.) below the soil surface unless the soil temperature regime is cryic or pergelic.

Oxic horizon

Summary of properties

In summary, the oxic horizon is a subsurface horizon, exclusive of the argillic or natric horizon, that

1. Is at least 30 cm thick;

2. Has a fine-earth fraction that retains 10 meq or less ammonium ions per 100 g clay from an unbuffered 1N NH_4Cl solution (meq of NH_4 retained per 100 g soil x 100/clay percentage[5] $\geq$10) or has <10 meq of bases extractable with NH_4OAc plus aluminum extractable with 1N KCl per 100 g clay;

3. Has an apparent cation-exchange capacity of the fine-earth fraction of 16 meq or less per 100 g clay by NH_4OAc unless there is an appreciable content of aluminum-interlayered chlorite (meq CEC per 100 g soil x 100/clay percentage $\leq$16, clay percentage as in footnote 5);

4. Does not have more than traces of primary aluminosilicates such as feldspars, micas, glass, and ferromagnesian minerals, as discussed earlier;

5. Has texture of sandy loam or finer in the fine-earth fraction and has >15 percent clay;

6. Has mostly gradual or diffuse boundaries between its subhorizons; and

7. Has <5 percent by volume that shows rock structure.

Duripan

The duripan (L. *durus,* hard, plus pan; meaning hardpan) is a subsurface horizon that is cemented by silica to the degree that fragments from the air-dry horizon do not slake during prolonged soaking in water or in HCl.

Summary of properties

In summary, the duripan is a silica-cemented subsurface horizon in which

1. Cementation is strong enough that dry fragments from some subhorizon do not slake in water, even during prolonged wetting;

2. Coatings of silica, insoluble in 1 *N* HCl even during prolonged soaking but soluble in hot concentrated KOH or in alternating acid and alkali, are present in some pores and on some structural faces; or some durinodes are present; and

3. Cementation is not destroyed by soaking in acid in more than half of any laminar capping that may be present or in some other continuous or imbricated subhorizon. Cementation in such layers is completely destroyed by hot concentrated KOH, either by a single treatment or by alternating with acid.

4. If fractured, the average lateral distance between fracture points is 10 cm or more.

Fragipan

A fragipan (modified from L. *fragilis,* brittle, and pan; meaning brittle pan) is a loamy or uncommonly a sandy subsurface horizon that may but does not necessarily underlie a cambic, spodic, argillic, or albic horizon. It has a very low content of organic matter, has high bulk density relative to the horizons above it, and is seemingly cemented when dry, having then hard or very hard consistence. When moist, a fragipan has moderate or weak brittleness, which is the tendency for a ped or clod to rupture suddenly when pressure is applied rather than to undergo slow deformation. A dry fragment slakes or fractures when placed in water. A fragipan is usually mottled, is slowly or very slowly permeable to water, and has few or many bleached, roughly vertical planes that are faces of coarse or very coarse polyhedrons or prisms.

Identification

There is no known laboratory procedure for identifying a sample of a fragipan. Identification is primarily a field problem. A combination of clues must be used because there is no single unique property of fragipans. First, position is important. A fragipan lies below an eluvial horizon unless the soil has been truncated, but it is not necessarily immediately below. If the soil has been truncated, the pan can be traced up slope until it lies under an eluvial horizon.

Second, if there is an argillic or a cambic horizon above a fragipan, there is commonly an A′2 horizon between the fragipan and the overlying horizon. The A′2 horizon is marked by uncoated grains of sand and silt. This horizon seems related to water that either stands above the pan or moves laterally along its surface.

Third, if the pan is not saturated for long periods, some or all pedons normally have bleached vertical streaks that form a roughly polygonal pattern on a horizontal plane. The bleached streaks are bounded by strong brown or reddish brown streaks where iron and manganese have accumulated. If the pan is saturated for long periods or if the texture is sandy, the polygonal color pattern may be absent.

Fourth, if the moisture content is near the wilting point, the matrix between the streaks is very firm. If it is near field capacity, the matrix is brittle. The brittle matrix should constitute 60 percent or more of the volume of some subhorizon.

Fifth, fine feeder roots are virtually absent in the brittle parts of a fragipan. If brittleness is so weakly expressed that fine feeder roots are present throughout the horizon, the horizon should not be considered a fragipan. It should be noted, however, that some trees have tap roots that extend through a well-expressed fragipan, but this is the exception rather than the rule. It is characteristic of fragipans that few or many roots may be present in the bleached vertical streaks and that few or no fine roots are present in the brittle matrix between the bleached streaks. The fine roots

should not be present at intervals of <10 cm except within bleached vertical streaks, and the mean horizontal dimensions of the brittle matrix should be at least 10 cm.

Sixth, texture of the fine-earth fraction of a fragipan is finer than fine sand, and the percentage of clay is generally <35; in most soils appreciably less. The texture normally is loamy, that is, silt loam, loam, or sandy loam.

Seventh, an air-dry fragment about the size of a fist slakes or fractures when placed in water.

Albic horizon

The albic (L. *albus,* white) horizon is one from which clay and free iron oxides have been removed or in which the oxides have been segregated to the extent that the color of the horizon is determined by the color of the primary sand and silt particles rather than by the coatings on these particles. An albic horizon may be at the surface of the mineral soil; it may lie just above an argillic or a spodic horizon; it may lie between a spodic horizon and either a fragipan or an argillic horizon; or it may lie between an argillic horizon and a fragipan or between a cambic horizon and an argillic horizon, natric horizon, or fragipan. It is usually underlain by a spodic, natric, or argillic horizon, a fragipan, or a relatively impervious layer that can produce a perched water table and either stagnant or moving water.

Deep deposits of pure white sand can be formed by wind or wave action. Although these deposits have the apparent morphology of an albic horizon, they are in fact a parent material. The white sand in such a deposit does not overlie a B horizon or any other soil horizon except, in some places, a buried soil.

An albic horizon, therefore, is defined as a surface or a lower horizon that has such thin or discontinuous coatings on the sand or silt particles that the hue and chroma of the horizon are determined chiefly by the color of the sand and silt particles.

The color value, moist, of an albic horizon is 4 or more, or the value, dry, is 5 or more, or both. If the value, dry, is 7 or more, or the value, moist, is 6 or more, the chroma is 3 or less either dry or moist. If the value, dry, is 5 or 6 or the value, moist, is 4 or 5, the chroma is closer to 2 than to 3 either dry or moist. If parent materials have a hue of 5YR or redder, a chroma, moist, of 3 is permitted in the albic horizon if the chroma is due to the color of uncoated silt or sand grains. Under an albic horizon there is usually a B horizon that is an argillic or a spodic horizon, but in some few sandy soils the underlying horizon is too weakly developed to meet the levels of accumulation required for those horizons.

Calcic horizon and ca horizon

The calcic horizon is a horizon of accumulation of calcium carbonate or of calcium and magnesium carbonate. The accumulation may be in the C horizon, but it may also be in a variety of other horizons such as a mollic

epipedon, an argillic or a natric horizon, or a duripan. The calcic horizon has two forms. In one, the underlying materials have less carbonate than the calcic horizon. This form of calcic horizon includes horizons of secondary carbonate enrichment that are 15 cm (6 in.) or more thick, have a carbonate content equivalent to ≥15 percent $CaCO_3$, and have a $CaCO_3$ equivalent at least 5 percent greater than the C horizon. In the other form, the calcic horizon is 15 cm or more thick, has a $CaCO_3$ equivalent ≥15 percent, and contains ≥5 percent, by volume, of identifiable secondary carbonates as pendants on pebbles, concretions, or soft powdery forms. If this calcic horizon rests on limestone, marl, or other very highly calcareous materials (≥40 percent $CaCO_3$ equivalent), the percentage of carbonates need not decrease with depth.

If the particle-size class is sandy, sandy-skeletal, coarse-loamy, or loamy-skeletal with less than 18 percent clay, the 15 percent requirement for $CaCO_3$ equivalent is waived. But to qualify as a calcic horizon, the horizon must have at least 5 percent (by volume) more soft powdery secondary $CaCO_3$ than an underlying horizon, and the calcic horizon must be at least 15 cm thick.

If a horizon enriched with secondary carbonate is indurated or cemented to the degree that dry fragments do not slake in water, it is considered to be a petrocalcic horizon, which is discussed later. Air-dry fragments of a calcic horizon will slake in water. Pendants below rocks and concretions normally do not slake, but these are not connected, and the soil material between the concretions will slake.

Gypsic horizon

The gypsic horizon is a noncemented or weakly cemented horizon of enrichment with secondary sulfates that is 15 cm or more thick, has at least 5 percent more gypsum than the C horizon or the underlying stratum, and in which the product of the thickness in centimeters and the percentage of gypsum is ≥150. Thus, a horizon 30 cm thick that has 5 percent gypsum qualifies if gypsum is absent in the underlying horizon. A layer 30 cm thick that has 6 percent gypsum qualifies if the gypsum content of the underlying horizon is not more than 1 percent. Cementation is weak enough that a dry fragment slakes in water.

The percentage of gypsum can be calculated by multiplying the milliequivalents of gypsum per 100 g soil by the milliequivalent weight of gypsum, which is 0.086.

Petrocalcic horizon

The petrocalcic horizon is a continuous, cemented or indurated calcic horizon that is cemented by calcium carbonate or in some places by calcium and some magnesium carbonate. Accessory silica may be present. The petrocalcic horizon is continuously cemented throughout

the pedon to the degree that dry fragments do not slake in water. It cannot be penetrated by spade or auger when dry. It is massive or platy, very hard or extremely hard when dry, and very firm or extremely firm when moist. Noncapillary pores are filled, and the petrocalcic horizon is a barrier to roots. Hydraulic conductivity is moderately slow to very slow. The horizon is usually much more than 10 cm (4 in.) thick.

A laminar capping commonly is present but is not required.

If a laminar horizon rests on bedrock, it is considered a petrocalcic horizon if it is 2.5 cm or more thick and the product of the thickness in centimeters multiplied by the percentage of $CaCO_3$ equivalent is 200 or more.

Petrogypsic horizon

The petrogypsic horzion is a gypsic horizon that is strongly enough cemented with gypsum that dry fragments do not slake in water and that roots cannot enter. The gypsum content commonly is far greater than the minimum requirements for the gypsic horizon and usually exceeds 60 percent. Petrogypsic horizons are restricted to arid climates and to parent materials that are rich in gypsum.

Salic horizon

A salic horizon is a horizon 15 cm or more thick that contains a secondary enrichment of salts more soluble in cold water than gypsum. It contains at least 2 percent salt, and the product of its thickness in centimeters and salt percentage by weight is 60 or more. Thus, a horizon 20 cm thick would need to contain 3 percent salt to qualify as a salic horizon and a horizon 30 cm thick would need 2 percent.

Sulfuric horizon

The sulfuric (L. *sulfur*) horizon is composed either of mineral or organic soil material that has both a pH <3.5 (1:1 in water) and jarosite mottles (the color of fresh straw that has a hue of 2.5Y or yellower and chroma of 6 or more).

A sulfuric horizon forms as a result of artificial drainage and oxidation of sulfide-rich mineral or organic materials. Such a horizon is highly toxic to plants and virtually free of living roots.

Other diagnostic soil characteristics

Abrupt textural change

An abrupt textural change is a change from an ochric epipedon or an albic horizon to an argillic horizon. There is, in the zone of contact, a very appreciable increase in clay

content within a very short distance in depth. If the clay content of the ochric epipedon or the albic horizon is <20 percent, the clay content should double within a distance in depth of 7.5 cm or less. If the clay content exceeds 20 percent, the increase in clay content should be at least 20 percent of the fine-earth fraction, for example, from 22 percent to 42 percent, within a distance of 7.5 cm in depth, and the clay content in some part of the argillic horizon should be at least double that of the horizon above.

A transitional horizon normally is not present or is too thin to be sampled. In some soils, however, there may be tonguing or interfingering of albic materials, which are defined later, in parts of the argillic horizon. The horizon boundary in such a soil is irregular or even discontinuous. The sampling of such a mixture as a single horizon might create the impression of a relatively thick transitional horizon, even though the thickness of the actual transition at the contact may be only 1 mm or so.

Amorphous material dominant in the exchange complex

Amorphous material, as the term is used here, is colloidal material that includes allophane and has all or most of the properties of allophane. The term is more inclusive, however, than allophane as it is defined by some workers. Amorphous material, as used here, is generally amorphous under X-ray analysis, but enough crystalline materials may be present, especially in mixtures, to cause small and disordered peaks. The amorphous material is associated with organic matter, but it contains aluminum, and it never has more than traces of aluminum that can be extracted with KCl. Consequently, if the base saturation is low, that is, <35 percent, the amorphous material has a permanent charge of less than 10 meq per 100 g. It has high exchange capacity, however, in a system buffered at pH 7, and very high exchange capacity at pH 8.2. The exchange capacity is clearly pH induced. The amorphous material also has high anion-exchange capacity. It has an enormous surface area and retains much water against 15-bar tension, commonly 50 to 100 percent or more. It cannot be dispersed readily in hexametaphosphate.

If amorphous material dominates an exchange complex, we find that the following conditions are satisfied:

1. The exchange capacity of the clay at pH 8.2 is >150 meq per 100 g measured clay, and commonly is >500 meq per 100 g. The high value is, in part, the result of the poor dispersion.

2. If there is enough clay to have a 15-bar water content of 20 percent or more, the pH of a suspension of 1 g soil in 50 ml 1 *N* NaF is >9.4 after 2 minutes.

3. The ratio of 15-bar water content to measured clay is more than 1.0.

4. The amount of organic carbon exceeds 0.6 percent.

5. Differential thermal analysis shows a low-temperature endotherm.

6. The bulk density of the fine-earth fraction is <0.85 g per cubic centimeter at 1/3-bar tension.

Coefficient of linear extensibility, COLE

This coefficient is the ratio of the difference between the moist length and the dry length of a clod to its dry length. It is *(Lm - Ld)/Ld,* where *Lm* is the length at 1/3-bar tension and *Ld* is the length when dry. It can be calculated from the difference in bulk density of the clod when moist and when dry. COLE can be estimated from shrinkage of a sample that has been packed at field capacity into a mold and then dried.

Durinodes

Durinodes (L. *durus,* hard; *nodus,* knot) are weakly cemented to indurated nodules. The cement is SiO_2, presumably opal and microcrystalline forms of silica. It breaks down in hot concentrated KOH after treatment with HCl to remove carbonates but does not break down with concentrated HCl alone. Dry durinodes do not slake appreciably in water, but prolonged soaking can result in spalling of very thin platelets and some slaking. The durinodes are firm or very firm; they are brittle when wet, both before and after treatment with acid; and they are disconnected and they range upward in size from a diameter of about 1 cm. Most durinodes are roughly concentric when viewed in cross section, and concentric stringers of opal may be visible under a hand lens.

Gilgai

Gilgai is the microrelief that is typical of clayey soils that have a high coefficient of expansion with changes in moisture content and that also have distinct seasonal changes in moisture content. The microrelief consists of either a succession of enclosed microbasins and microknolls in nearly level areas or of microvalleys and microridges that run up and down the slope. The height of the microridges commonly ranges from a few centimeters to 1 m. Rarely does the height approach 2 m.

Lithic contact

A lithic contact is a boundary between soil and coherent underlying material. Except in Ruptic-Lithic subgroups the underlying material must be continuous within the limits of a pedon except for cracks produced in place without significant displacement of the pieces. Cracks should be few, and their average horizontal spacing should be 10 cm or more. The underlying material must be sufficiently coherent when moist to make hand digging with a spade impractical, although it may be chipped or scraped with a spade. If it is a single mineral, it must have a hardness by Mohs scale of 3 or more. If it is not a single mineral, chunks of gravel size that can be broken out must not disperse during shaking

for 15 hours in water or in sodium hexametaphosphate solution. The underlying material considered here does not include diagnostic soil horizons such as duripan or a petrocalcic horizon.

A lithic contact is diagnostic at the subgroup level if it is within 50 cm of the surface of a mineral soil.

Mottles that have chroma of 2 or less

It refers to colors in a horizon in which parts have chroma of 2 or less, moist, and value, moist, of 4 or more, whether or not that part is dominant in volume or whether or not it is a continuous phase surrounding spots of higher chroma. If either the minor or major part of a horizon has chroma of 1 to 2 and value, moist, or 4 or more and there are spots of higher chroma, the part that has the lower chroma is included in the meaning of "mottles that have chroma of 2 or less." The part is excluded from the meaning if all the horizon has chroma of 2 or less or if no part of the horizon has chroma as low as 2.

The phrase also means that the horizon that has such mottles is saturated with water at some period of the year or the soil is artificially drained. It is also implicit in the meaning that the temperature of the horizon is above the biologic zero, which is about 5° C (41° F), during at least a part of the time that the horizon is saturated.

n value

The *n* value (Pons and Zonneveld 1965) refers to the relation between the percentage of water under field conditions and the percentages of inorganic clay and of humus. The *n* value is helpful in predicting whether the soil may be grazed by livestock or will support other loads and the degree of subsidence that would occur after drainage. The *n* value can be calculated for mineral soil materials that are not thixotropic by the formula:

$n = (A - 0.2R)/(L + 3H)$

A is the percentage of water in the soil in field condition, calculated on a dry-soil basis; *R* is the percentage of silt plus sand; *L* is the percentage of clay; and *H* is the percentage of organic matter (organic carbon x 1.724).

Few data are available in the United States for calculations of the *n* value, but the critical *n* value of 0.7 can be approximated closely in the field by a simple test of squeezing the soil in the hand. If the soil flows with difficulty between the fingers, the *n* value is between 0.7 and 1.0. If the soil flows easily between the fingers, the *n* value is 1 or more.

Organic soil materials

Organic soil materials either

1. Are saturated with water for long periods or are artificially drained, and have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, 12 percent

or more organic carbon if the mineral fraction has no clay, or a proportional amount of organic carbon between 12 and 18 percent if the clay content is between zero and 60 percent; or

2. Are never saturated with water for more than a few days and have 20 percent or more organic carbon.

Item 1 in this definition covers materials that have been called peat and muck. Item 2 is intended to include materials that have been called "litter" or O horizons. Not all organic soil materials accumulate under water. Leaf litter may rest on a lithic contact and yet may support a forest. The only "soil" in this situation is organic in the sense that the mineral fraction may be appreciably less than half the weight and only a small proportion of the volume of the soil.

Paralithic contact

A paralithic (lithiclike) contact is a boundary between soil and continuous coherent underlying material. It differs from a lithic contact in that the underlying material, if a single mineral, has a hardness by Mohs scale of <3. If the underlying material is not a single mineral, chunks of gravel size that can be broken out disperse more or less completely during 15 hours of end-over-end shaking in water or in sodium hexametaphosphate solution and, when moist, the material can be dug with difficulty with a spade.

Permafrost

Permafrost is a layer in which the temperature is perennially at or below 0° C, whether the consistence is very hard or loose. Dry permafrost has loose consistence.

Petroferric contact

A petroferric (Gr. *petra,* rock, and L. *ferrum,* iron; implying ironstone) contact is a boundary between soil and a continuous layer of indurated material in which iron is an important cement and organic matter is absent or is present only in traces. The indurated layer must be continuous within the limits of a pedon but may be fractured if the average lateral distance between fractures is ≥ 10 cm. The indurated layer is distinguished from a placic horizon and from an indurated spodic horizon (ortstein) because it contains little or no organic matter. Organic matter is present in both the other horizons.

Several features can aid in making the distinction between a lithic and a petroferric contact. First, a petroferric contact is roughly horizontal. Second, the amount of iron in the material immediately below a petroferric contact is high. The content of Fe_2O_3 normally ranges upward from 30 percent. Third, the ironstone sheets below a petroferric contact are thin. Their thickness ranges from a few centimeters to a very few meters. Sandstone, on the other hand, may be thin or very thick, may be level bedded or tilted,

and may have only a small percentage of Fe_2O_3. In the Tropics the ironstone commonly is more or less vesicular.

Plinthite

Plinthite (Gr. *plinthos,* brick) is an iron-rich, humuspoor mixture of clay with quartz and other diluents. It commonly occurs as dark red mottles, which usually are in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on exposure to repeated wetting and drying, especially if it is exposed also to heat from the sun. The lower boundary of a zone in which plinthite occurs usually is diffuse or gradual, but it may be abrupt at a lithologic discontinuity.

Generally, plinthite forms in a horizon that is saturated with water at some season. The original segregation of the iron normally is in the form of soft, more or less clayey, red or dark red mottles. The mottles are not considered plinthite unless there has been enough segregation of iron to permit irreversible hardening on exposure to wetting and drying. Plinthite in the soil usually is firm or very firm when the soil moisture content is near field capacity and hard when the moisture content is below the wilting point. Plinthite does not harden irreversibly as a result of a single cycle of drying and rewetting. After a single drying, it will remoisten, and then it can be dispersed in large part by shaking in water with a dispersing agent.

In a moist soil, plinthite is soft enough that it can be cut with a spade. After irreversible hardening, it is no longer considered plinthite but is called ironstone. Indurated ironstone materials can be broken or shattered with a spade but cannot be dispersed by shaking in water with a dispersing agent.

Potential linear extensibility

This characteristic is the sum of the products, for each horizon, of the thickness of the horizon in centimeters and the COLE of the horizon.

Sequum: number and kind

A sequence of an eluvial horizon and its subjacent B horizon, if one is present, is called a sequum. An albic horizon and a spodic horizon immediately underlying it, for example, constitute a sequum. Similarly, a mollic epipedon over a cambic horizon or an argillic horizon over a ca horizon also constitute a sequum. Two sequa may be present in vertical sequence in a single soil, and that sequence is called a bisequum.

Slickensides

Slickensides are polished and grooved surfaces that are produced by one mass sliding past another. Some of them occur at the base of a slip surface where a mass of soil moves downward on a relatively steep slope. Slickensides

are very common in swelling clays in which there are marked changes in moisture content. Plate 7C is a photograph of such a slickenside.

Soft powdery lime

Soft powdery lime is a phrase that is used in the definitions of a number of taxa. It refers to translocated authigenic lime, soft enough to be cut readily with a fingernail, that was precipitated in place from the soil solution rather than inherited from a soil parent material such as a calcareous loess or till. It should be present in a significant enough accumulation to constitute a ca horizon.

To be identifiable, soft powdery lime must have some relation to the soil structure or fabric. It may disrupt the fabric to form spheroidal aggregates, or white eyes, that are soft and powdery when dry. Or the lime may be present as soft coatings in pores or on structural faces. If present as coatings, it covers a significant part of the surface. Commonly, it coats the whole surface to a thickness of 1 to 5 mm or more. But only part of a surface may be coated if little lime is present in the soil. The coatings should be thick enough to be visible when moist and should cover a continuous area large enough to be more than filaments. The pseudomycelia commonly seen in a dry calcareous horizon do not come within the meaning of soft powdery lime. Pseudomycelia are soft powdery filaments on structural faces, commonly branching, but they may come and go with the seasons and may be only lime that was precipitated in a single season by the withdrawal of stored soil moisture rather than a ca horizon.

Soft coatings on hard lime concretions are also excluded from the meaning of soft powdery lime. These may be thin or thick, and they may be the result of either current accumulation or removal of lime. That is, the concretion may be growing or may be undergoing dissolution, and either process can produce a soft coating.

Soil moisture regimes

The soil moisture regime, as the term is used here, refers to the presence or absence either of ground water or of water held at a tension <15 bars in the soil or in specific horizons by periods of the year. Water held at a tension of 15 bars or more is not available to keep most mesophytic plants alive. The availability of water also is affected by dissolved salts. A soil may be saturated with water that is too salty to be available to most plants, but it would seem better to call such a soil salty rather than dry. Consequently, we consider a horizon to be dry when the moisture tension is 15 bars or more. If water is held at a tension of <15 bars but more than zero, we consider the horizon to be moist. A soil may be continuously moist in some or all horizons throughout the year or for some part of the year. It may be moist in winter and dry in summer or the reverse. In the northern hemisphere, summer refers to the months

of June, July, and August, and winter means December, January, and February. A soil or a horizon is considered to be saturated with water when water stands in an unlined borehole close enough to the soil surface or to the horizon in question that the capillary fringe[6] reaches the surface or the top of the horizon.

Soil moisture control section

The intent in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from climatic data. The upper boundary of this control section is the depth to which a dry (tension >15 bars but not air dry) soil will be moistened by 2.5 cm (1 in.) of water within 24 hours. The lower boundary is the depth to which a dry soil will be moistened by 7.5 cm (3 in.) of water within 48 hours. These depths are exclusive of the depth of moistening along any cracks or animal burrows that are open to the surface.

If 7.5 cm of water moistens the soil to a lithic, petroferric, or paralithic contact or to a petrocalcic horizon or a duripan, the upper boundary of the rock or of the cemented horizon is the lower boundary of the soil moisture control section. If 2.5 cm of water moistens the soil to one of these contacts or horizons, the soil moisture control section is the lithic contact itself, the paralithic contact, or the upper boundary of the cemented horizon. The control section of the latter soil is moist if the upper boundary of the rock or the cemented horizon has a thin film of water. If the upper boundary is dry, the control section is dry.

As a rough guide to the limits, the soil moisture control seciton lies approximately between 10 and 30 cm (4 and 12 in.) if the particle-size class is fine-loamy, coarse-silty, fine-silty, or clayey. The control section extends approximately from a depth of 20 cm to a depth of 60 cm (8 to 24 in.) if the particle-size class is coarse-loamy, and from 30 to 90 cm (12 to 35 in.) if the particle-size class is sandy.

Classes of soil moisture regimes

The moisture regimes are defined in terms of the ground-water level and in terms of the presence or absence of water held at a tension <15 bars in the moisture control section by periods of the year. It is assumed in the definitions that the soil supports whatever vegetation it is capable of supporting. In other words, it is in crops, grass, or native vegetation; it is not being fallowed to increase the amount of stored moisture, nor is it being irrigated by man. These cultural practices affect the soil moisture condition as long as they are continued.

Aquic moisture regime.—The aquic (L. *aqua,* water) moisture regime implies a reducing regime that is virtually free of dissolved oxygen because the soil is saturated by ground water or by water of the capillary fringe. An aquic regime must be a reducing one. Some soil horizons, at times, are saturated with water while dissolved oxygen is present, either because the water is moving or because the environment is unfavorable for micro-organisms, for

example, if the temperature is $<1°C$ such a regime is not considered aquic.

For differentiation in the highest categories of soils that have an aquic regime, the whole soil must be saturated. In the subgroups, only the lower horizons are saturated. The soil is considered to be saturated if water stands in an unlined borehole at such a shallow depth that the capillary fringe (see footnote 6) reaches the soil surface except in noncapillary pores. The water in the borehole is stagnant and remains colored if a dye is placed in the water. In a sandy soil, the thickness of the capillary fringe may be only 10 to 15 cm. In a loamy or clayey soil that does not shrink or swell appreciably, the thickness may be 30 cm or more, depending on the size distribution of the pores.

The duration of the period that the soil must be saturated to have an aquic regime is not known. The duration must be at least a few days, because it is implicit in the concept that dissolved oxygen is virtually absent. Because dissolved oxygen is removed from ground water by respiration of micro-organisms, roots and soil fauna, it is also implicit in the concept that the soil temperature is above biologic zero (5° C) at some time while the soil or the horizon is saturated.

Very commonly, the level of ground water fluctuates with the seasons. The level is highest in the rainy season, or in fall, winter, or spring if cold weather virtually stops evapotranspiration. There are soils, however, in which the ground water is always at or very close to the surface. A tidal marsh and a closed, landlocked depression fed by perennial streams are examples. The moisture regime in these soils is called "peraquic." Although the term is not used as a formative element for names of taxa, it is used in their descriptions as an aid in understanding genesis.

Aridic and torric moisture regimes.—These terms (L. *aridus,* dry, and L. *torridus,*[7] hot and dry) are used for the same moisture regime but in different categories of the taxonomy.

In the aridic (torric) moisture regime, the moisture control section in most years is

1. Dry in all parts more than half the time (cumulative) that the soil temperature at a depth of 50 cm is above 5° C; and

2. Never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 50 cm is above 8° C.

Soils that have an aridic or a torric moisture regime are normally in arid climates. A few are in semiarid climates and either have physical properties that keep them dry, such as a crusty surface that virtually precludes infiltration of water, or they are very shallow over bedrock. There is little or no leaching in these moisture regimes, and soluble salts accumulate in the soil if there is a source of them.

The limits of soil temperature exclude from these moisture regimes the very cold and dry regions of Greenland and adjacent islands. Such fragmentary data are available

on the soils of those regions that no provision is made for their moisture regimes in this taxonomy.

Udic moisture regime.—The udic (L. *udus,* humid) moisture regime implies that in most years the soil moisture control section is not dry in any part for as long as 90 days (cumulative). If the mean annual soil temperature is lower than 22° C and if the mean winter and mean summer soil temperatures at a depth of 50 cm differ by 5° C or more, the soil moisture control section is not dry in all parts for as long as 45 consecutive days in the 4 months that follow the summer solstice in 6 or more years out of 10. In addition, the udic moisture regime requires, except for short periods, a three-phase system, solid-liquid-gas, in part, but not necessarily in all, of the soil when the soil temperature is above 5° C.

The udic moisture regime is common to the soils of humid climates that have well-distributed rainfall or that have enough rain in summer that the amount of stored moisture plus rainfall is approximately equal to or exceeds the amount of evapotranspiration. Water moves down through the soil at some time in most years.

If precipitation exceeds evapotranspiration in all months of most years, there are occasional brief periods when some stored moisture is used, but the moisture tension rarely becomes as great as 1 bar in the soil moisture control section. The water moves through the soil in all months that it is not frozen. This extremely wet moisture regime is called "perudic" (L. *per,* throughout in time, L. *udus,* moist). The formative element *ud* is used in the names of most taxa to indicate either a udic or a perudic regime. The term "perudic" is not used in names of taxa, but is used in the text if it is relevant to the genesis of the soils.

Ustic moisture regime.—The ustic (L. *ustus,* burnt, implying dryness) moisture regime is intermediate between the aridic and the udic regime. The concept is one of limited moisture, but the moisture is present at a time when conditions are suitable for plant growth. The ustic moisture regime is not applied to soils that have cryic or pergelic temperature regimes, which are defined later.

If the mean annual soil temperature is 22° C or higher or if the mean summer and winter soil temperatures differ by $<5°$ C at a depth of 50 cm, the soil moisture control section in the ustic moisture regime is dry in some or all parts for 90 or more cumulative days in most years. But the moisture control section is moist in some part for more than 180 cumulative days, or it is continuously moist in some part for at least 90 consecutive days.

If the mean annual soil temperature is lower than 22° C and if the mean summer and winter soil temperatures differ by 5° C or more at a depth of 50 cm, the soil moisture control section in the ustic regime is dry in some or all parts for 90 or more cumulative days in most years. But it is not dry in all parts for more than half the time that the soil temperature is higher than 5° C at a depth of 50 cm (the aridic and torric regimes). Also, it is not dry in all parts for as long as 45 consecutive days in the 4 months that follow

the summer solstice in 6 or more years out of 10 if the moisture control section is moist in all parts for 45 or more consecutive days in the 4 months that follow the winter solstice in 6 or more years out of 10 (xeric regime).

In tropical and subtropical regions that have either one or two dry seasons, summer and winter have little meaning. In those regions, the ustic regime is that typified in a monsoon climate that has at least one rainy season of 3 months or more. In temperate regions of subhumid or semiarid climates, the rainy seasons are usually spring and summer or spring and fall, but never winter. Native plants are mostly annuals or they have a dormant period while the soil is dry.

Xeric moisture regime.—The xeric moisture regime (Gr. *xeros,* dry) is that typified in Mediterranean climates, where winters are moist and cool and summers are warm and dry. The moisture, coming in winter when potential evapotranspiration is at a minimum, is particularly effective for leaching. In a xeric moisture regime, the soil moisture control section is dry in all parts for 45 or more consecutive days within the 4 months that follow the summer solstice in 6 or more years out of 10. It is moist in all parts for 45 or more consecutive days within the 4 months that follow the winter solstice in 6 or more years out of 10. The moisture control section is moist in some part more than half the time, cumulative, that the soil temperature at a depth of 50 cm is higher than 5° C, or in 6 or more years out of 10 it is moist in some part for at least 90 consecutive days when the soil temperature at a depth of 50 cm is continuously higher than 8°C. In addition, the mean annual soil temperature is lower than 22°C, and mean summer and mean winter soil temperatures differ by 5° C or more at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Soil temperature regimes

Classes of soil temperature regimes

The following soil temperature regimes are used in defining classes at various categoric levels in the taxonomy.

Pergelic.—Soils with a pergelic (L. *per,* throughout in time and space, and L. *gelare,* to freeze; connoting permanent frost) temperature regime have a mean annual temperature lower than 0°C. These are soils that have permafrost if they are moist, or dry frost if excess water is not present. It seems likely that the moist and the dry pergelic regimes should be defined separately, but at present we have only fragmentary data on the dry soils of very high latitudes.

Cryic.—In this regime (Gr. *kryos,* coldness; connoting very cold soils) soils have a mean annual temperature higher than 0° C (32° F) but lower than 8° C (47° F).

1. In mineral soils, the mean summer soil temperature (June, July, and August in the northern hemisphere and December, January, and February in the southern hemi-

sphere) at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, is as follows:

a. If the soil is not saturated with water during some part of the summer and

(1) There is no O horizon, lower than 15°C (59°F);

(2) There is an O horizon, lower than 8°C (47°F);

b. If the soil is saturated with water during some part of the summer and

(1) There is no O horizon, lower than 13°C (55°F);

(2) There is an O horizon or a histic epipedon, lower than 6°C (43°F).

2. In organic soils, either

a. The soil is frozen in some layer within the control section in most years about 2 months after the summer solstice; that is, the soil is very cold in winter but warms up slightly in summer; or

b. The soil is not frozen in most years below a depth of 5 cm; that is, the soil is cold throughout the year but, because of marine influence, does not freeze in most years.

Cryic soils that have an aquic moisture regime commonly are churned by frost.

Most isofrigid soils with a mean annual soil temperature above 0°C have a cryic temperature regime. A few with organic materials in the upper part are exceptions. Throughout this text all isofrigid soils without permafrost are considered to have a cryic temperature regime.

Frigid.—The frigid regime and some of the others that follow are used chiefly in defining classes of soils in the low categories. In the frigid regime the soil is warmer in summer than one in the cryic regime, but its mean annual temperature is lower than 8°C (47°F), and the difference between mean winter and mean summer soil temperature is more than 5°C (9°F) at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Mesic.—The mean annual soil temperature is 8°C or higher but lower than 15°C (59°F), and the difference between mean summer and mean winter soil temperature is more than 5°C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Thermic.—The mean annual soil temperature is 15°C (59°F) or higher but lower than 22°C (72°F), and the difference between mean summer and mean winter soil temperature is more than 5°C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Hyperthermic.—The mean annual soil temperature is 22°C (72°F) or higher, and the difference between mean summer and mean winter soil temperature is more than 5°C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

If the name of a soil temperature regime has the prefix iso, the mean summer and winter soil temperatures for June, July, and August and for December, January, and

February differ by less than 5° C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Isofrigid.—The mean annual soil temperature is lower than 8° C (47° F).

Isomesic.—The mean annual soil temperature is 8° C or higher but lower than 15° C (59° F).

Isothermic.—The mean annual soil temperature is 15° C or higher but lower than 22° C (72° F).

Isohyperthermic.—The mean annual soil temperature is 22° C or higher.

The limit between isofrigid and isomesic cannot be tested in the United States and is tentative.

Sulfidic materials

Sulfidic materials are waterlogged mineral or organic soil materials that contain 0.75 percent or more sulfur (dry weight), mostly in the form of sulfides and that have less than three times as much carbonate ($CaCO_3$ equivalent) as sulfur. Sulfidic materials accumulate in a soil that is permanently saturated, generally with brackish water. The sulfates in the water are biologically reduced to sulfides as the soil materials accumulate. Sulfidic materials are most common in coastal marshes near the mouths of rivers that carry noncalcareous sediments, but they may occur in fresh-water marshes if there is sulfur in the water. If the soil is drained, the sulfides oxidize and form sulfuric acid. The pH, which normally is near neutrality before drainage, may drop below 2. The acid reacts with the soil to form iron and aluminum sulfates. The iron sulfate, jarosite, segregates and forms the bright-yellow mottles that characterize a sulfuric horizon. The transition from sulfidic materials to a sulfuric horizon normally requires a very few years. A sample of sulfidic materials, if air dried slowly in shade for about 2 months with occasional remoistening, becomes extremely acid. For quick identification in the field, a sample can be oxidized by boiling in concentrated H_2O_2 and measuring the drop in pH.[8]

Thixotropy

Thixotropy is "a reversible gel-sol transformation under isothermal shearing stress following rest" (Webster's 1967). The term means "to change by touch." Many kinds of thixotropic substances have been identified and studied, including some sesquioxide gels, kaolinite gels, montmorillonite gels, greases, inks, paints, protoplasm, blood coagula, nitrocellulose solutions, and drilling muds. Thixotropy apparently is the result of a kind of structure that, if broken down, can rebuild itself. The breakdown may be caused by one of several actions: by agitation, by shearing, or even by ultrasonic waves. Some natural (untreated) soil materials exhibit this property. A field test of thixotropic soil is this: Press a bit of wet soil between thumb and forefinger; at first it resists deformation, having some rigidity, or elasticity, or both; under increasing pressure the soil can be molded and

deformed; under greater pressure, suddenly the soil changes from a plastic solid to a liquid, and the fingers skid. After the soil smears in this fashion, usually free water can be seen on the fingers. In a matter of a second or two the liquefied soil sets again to its original solid state. If a knife blade is pushed into the soil mass in a pit and removed suddenly, it has only a staining of muddy water; if pressed into the soil and slowly pulled out, a large mass of soil adheres to the blade. In the literature of soils of western United States, particularly of Hawaii, the consistence term "smeary" is used to characterize soil materials that are thixotropic.

Tonguing and interfingering

Tonguing of albic materials

Tongues of albic materials consist of penetrations of bleached material that has the color of an albic horizon in an argillic or a natric horizon, along ped surfaces if peds are present. No continuous albic horizon need be present above the tongues. The penetrations have a vertical dimension of >5 cm in any argillic or natric horizon. Their horizontal dimension is 5 mm or more in a fine-textured argillic or natric horizon (clay, silty clay, or sandy clay), 10 mm or more in a moderately fine textured argillic or natric horizon (clay loam, sandy clay loam, or silty clay loam), and 15 mm or more in a medium or coarser textured argillic or natric horizon (silt loam, loam, very fine sandy loam, or coarser). The penetrations must occupy more than 15 percent of the matrix of some part of the argillic or natric horizon before they are considered tongues.

Interfingering of albic materials

Interfingering of albic materials consists of penetrations of albic materials into an underlying argillic or natric horizon along faces of peds, primarily along vertical faces but to a lesser degree along horizontal faces. No continuous albic horizon need be present. The penetrations are not wide enough to constitute tonguing, but they form continuous skeletans (ped coatings of clean silt or sand defined by Brewer, 1964) >1 mm thick on the vertical ped faces, which means a total width >2 mm between abutting peds. Because quartz is such a common constiutent of soils, the skeltans usually appear to be nearly white when dry and light gray when moist, but their color is determined in large part by the color of the sand or silt fraction.

To be recognized as interfingering, all the following requirements must be met in a horizon that is 5 cm or more thick:

1. Half or more of the matrix consists of peds of the argillic or natric horizon;

2. Albic materials are thicker than 2 mm on vertical faces between abutting peds but are too thin to be tongues;

3. Clay skins are present in the peds, at least in pores.

Albic materials meet the following requirements for color. If the value, dry, is 7 or more, or the value, moist, is 6 or more, the chroma is 3 or less either dry or moist. If the value, dry, is 5 or 6 and the value, moist, is 4 or 5, the chroma is closer to 2 than to 3 either dry or moist.

Weatherable minerals

Several references are made to weatherable minerals in the text of this chapter and later chapters. Obviously, the stability of a mineral in a soil is a partial function of the soil moisture regime. In the context of the references in the definitions of diagnostic horizons and of various taxa, a humid climate is always assumed, either present or past. Minerals that are included in the meaning of weatherable minerals are:

1. Clay minerals: All 2:1 lattice clays except one that is currently considered to be an aluminum-interlayered chlorite. Sepiolite, talc, and glauconite are also included in the meaning of this group of weatherable clay minerals, although they are not everywhere of clay size.

2. Silt- and sand-size minerals (0.02 to 0.2 mm in diameter): Feldspars, feldspathoids, ferromagnesian minerals, glass, micas, zeolites, and apatite.

It should be noted that this is a restricted meaning of weatherable minerals. Calcite, for example, is readily soluble in a humid environment. If it is dissolved, it leaves no trace or residue. Soils that have been intensely and deeply weathered in a humid environment of the past are, in some places, preserved today in an arid environment. Calcite could reappear in one of these soils if it were brought in as dust. The intent is to include, in the context of the meaning of weatherable minerals for this purpose, only those minerals that are unstable in a humid climate relative to other minerals, such as quartz and 1:1 lattice clays, and that are more resistant to weathering than calcite.

Footnotes

[1] The chroma is permitted to range up to but not to include 4.0 in soils that have a hyperthermic or isohyperthermic temperature regime. The color when moist is that of a specimen that is moist enough that an additional drop of water produces no change in the color. The color when dry is that of a specimen dry enough that continued drying produces no further change.

[2] See footnote 1.

[3] The percentage of exchangeable sodium (ESP) is used in the definition of the natric horizon and in a number of the taxa. Since this text was written, the U.S. Salinity Laboratory (personal communication from C. A. Bower) has revised its definition of sodic (alkali) soils and the method for measuring the sodium adsorption ratio (SAR) as follows: SAR is measured by the normal method if the conductivity (EC) of the saturation extract is <20 mmhos per cm at 25° C. If the conductivity is ≥ 20 mmhos and SAR is >10, SAR is determined on a sample that has been leached with distilled water until EC of the leachate decreases to about 4 mmhos per centimeter but not to <4. ESP of ≥ 15 is replaced by SAR of ≥ 13 if EC is large enough to require a correction for soluble salts in calculating ESP. If EC is low enough (≤ 4) that no correction is needed for soluble salts, ESP is determined directly from the replaced cations.

[4] A thin black horizon that has color value of 2 or less may overlie this horizon.

[5] The percentage of clay as measured by the pipette method or 2.5 times 15-bar water, whichever value is higher but not more than 100.

[6] The capillary fringe is the zone just above the water table (zero gauge pressure) that remains almost saturated (Soil Sci. Soc. Amer. Glossary, 1965, p. 332).

[7] *Torridus* is not the ideal root, but a better one could not be found. Although soils may not be hot throughout the year, soils that have a torric moisture regime are hot and dry in summer.

[8] Concentrated H_2O_2 can cause serious burns and is dangerous. Gloves should be worn, and precautions should be taken against spilling, leakage, or spattering.

Chapter 2
Horizons and Properties Diagnostic for the Higher Categories: Organic Soils

ORG

Organic soil materials

Organic soil materials and organic soils

1. Are saturated with water for long periods or are artificially drained and, excluding live roots, (a) have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, (b) have 12 percent or more organic carbon if the mineral fraction has no clay, or (c) have a proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent; or

2. Are never saturated with water for more than a few days and have 20 percent or more organic carbon.

Definition of organic soils

Organic soils (Histosols) are soils that

1. Have organic soil materials that extend from the surface to one of the following:

a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or

b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or

2. Have organic materials that have an upper boundary within 40 cm of the surface and

a. Have one of the following thicknesses:

(1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that

(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within a depth of 40 cm from the surface; and

(2) Do not have mineral layers, taken cumula-

tively, as thick as 40 cm within the upper 80 cm.

It is a general rule that a soil is classed as an organic soil (Histosol) either if more than half of the upper 80 cm (32 in.) of soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic materials.

Kinds of organic soil materials

Three basic kinds of organic soil materials are distinguished, fibric, hemic, and sapric, according to the degree of decomposition of the orginial plant materials.

Fibers

A fiber is a fragment or piece of plant tissue, excluding live roots, that is large enough to be retained on a 100-mesh sieve (openings 0.15 mm in diameter) and that retains recognizable cellular structure of the plant from which it came. The material is screened after dispersion in sodium hexametaphosphate. Fragments larger than 2 cm in cross section or in their smallest dimension, to be called fibers, must be decomposed enough that they can be crushed and shredded with the fingers. Fragments of wood that are larger than 2 cm in cross section and that are so undecomposed that they cannot be crushed and shredded with the fingers are not considered fibers.

Fibric soil materials (L. *fibra,* fiber)

Fibric soil materials have the following characteristics:

1. The fiber content after rubbing is three-fourths[1] or more of the soil volume, excluding coarse fragments and mineral layers; or

2. The fiber content after rubbing is two-fifths or more of the soil volume, excluding coarse fragments and mineral layers, and the material yields a sodium pyrophosphate extract color on white chromatographic paper that has value and chroma of 7/1, 7/2, 8/1, 8/2, or 8/3.

Hemic soil materials

Hemic soil materials (Gr. *hemi,* half; implying intermediate decomposition) are intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric materials. They have morphological features that give intermediate values for fiber content, bulk density, and water content. They are partly altered both physically and biochemically.

Sapric soil materials (Gr. *sapros,* rotten)

These are the most highly decomposed of the organic materials. They normally have the smallest amount of plant fiber, the highest bulk density, and the lowest water content on a dry-weight basis at saturation. They are commonly

very dary gray to black. They are relatively stable, i.e., they change very little physically and chemically with time in comparison to the others.

Sapric materials have the following characteristics:

1. The fiber content after rubbing is less than one-sixth of the soil volume, excluding coarse fragments and mineral layers; and

2. The sodium pyrophosphate extract color on chromatographic paper is below or to the right of a line drawn to exclude blocks 5/1, 6/2, and 7/3 on the chart.

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Humilluvic materials

Illuvial humus accumulates in the lower parts of some organic soils if they are acid and have been drained and cultivated. The illuvial humus has a younger ^{14}C age than the overlying organic materials. It has very high solubility in sodium pyrophosphate and rewets very slowly after drying. Most commonly it accumulates near a contact with a sandy mineral horizon.

To be recognized as a differentia in classification, the illuvial humus should constitute at least half the volume of a layer at least 2 cm thick.

Limnic materials

Limnic materials include both organic and inorganic materials that were either (1) deposited in water by precipitation or through the action of aquatic organisms such as algae or diatoms, or (2) derived from underwater and floating aquatic plants and subsequently modified by aquatic animals. They include coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

Coprogenous earth

A coprogenous earth (sedimentary peat) layer is a limnic layer that

1. Contains many fecal pellets a few hundredths to a few tenths of a millimeter in diameter;

2. Has a color value, moist, <5;

3. Either forms a slightly viscous water suspension and is slightly plastic but not sticky or shrinks upon drying to form clods that are difficult to rewet and that often tend to crack along horizontal planes;

4. Is normally but not necessarily nearly devoid of fragments of plants that can be recognized with the eye; and

5. Yields a saturated sodium pyrophosphate extract on white filter paper that has higher color value and lower chroma than 10YR 7/3 or the cation-exchange capacity is <240 meq per 100 g of organic matter (measured by loss on ignition) or both.

Diatomaceous earth

A diatomaceous earth layer is a limnic layer that

1. Has a matrix color value of 3 through 5 if not previously dried, and the value changes irreversibly on drying. The color change results from irreversible shrinkage of organic

matter coatings on diatoms, which can be identified by microscopic (440X) examination of dry samples; and

2. Yields a color higher in value and lower in chroma than 10YR 7/3 on white filter paper that is inserted into a paste made of the material in a saturated sodium pyrophosphate solution or the cation-exchange capacity is <240 meq per 100 g of organic matter (by loss on ignition) or both.

Marl

A marl layer is a limnic layer that

1. Has a color value, moist, of 5 or more; and

2. Reacts with dilute HCl to evolve CO_2.

Marl usually does not change color irreversibly on drying. A layer of marl contains too little organic matter to coat the carbonate, even before it has been shrunk by drying.

Thickness of organic materials (control section)

For practical reasons an arbitrary control section has been established for taxonomy of Histosols. It is either 130 cm (51 in.) or 160 cm (63 in.) thick, depending on the kind of material, provided that no lithic or paralithic contact, thick layer of water, or frozen soil occurs within those limits. The thicker control section is used if the surface layer to a depth of 60 cm (24 in.) has three-fourths or more fibers derived from *Sphagnum* or from *Hypnum* or other mosses or has a bulk density <0.1. Layers of water may be thin or thick, from a few centimeters to many meters. Water is taken as the base of the control section only if the water extends below a depth of 130 cm or 160 cm, depending on the kind of material above it. A lithic or a paralithic contact shallower than 130 cm (51 in.) or 160 cm (63 in.), depending on the kind of material above it, is taken as the base of the control section, or the base is placed 25 cm (10 in.) below the depth at which the soil is frozen about 2 months after the summer solstice. An unconsolidated mineral substratum shallower than those limits does not change the base of the control section.

The control section has been divided somewhat arbitrarily into three tiers, the surface, subsurface, and bottom tiers.

Surface tier

The surface tier is the upper 60 cm (24 in.) if (1) the materials is fibric and three-fourths or more of the fiber volume is derived from *Sphagnum* or mosses or (2) the material has a bulk density <0.1; otherwise, the surface tier is the top 30 cm (12 in.) exclusive of loose surface litter or living mosses.

A surface mineral layer <40 cm (16 in.) thick is present on some organic soils as a result of flooding, additions by men to increase soil strength or reduce frost hazard, volcanic eruptions, or other causes. If present, it is considered a part of the surface tier, even though it may be >30 cm thick, and the depth then is measured from the top of the mineral layer.

Subsurface tier

The subsurface tier is 60 cm (24 in.) thick unless the control section ends at a lithic or paralithic contact or at water within this depth or unless the soil is frozen at too shallow a depth. In any of these situations the subsurface tier extends from the base of the surface tier to the base of the control section. It includes any unconsolidated mineral layers that may be present within those depths.

Bottom tier

The bottom tier is 40 cm (16 in.) thick unless the control section stops within the maximum span.

Family differentiae for mineral soils

The differentiae used to distinguish families of mineral soils within a subgroup are listed next in the order in which the descriptive terms appear in the family name and in which the terms are defined in this chapter.

- Particle-size classes
- Mineralogy classes
- Calcareous and reaction classes
- Soil temperature classes
- Soil depth classes
- Soil slopes classes
- Soil consistence classes
- Classes of coatings (on sand)
- Classes of cracks

Chapter 3
Family Differentiae

Mineral Soils

Particle-size classes

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Particle size refers to grain-size distribution of the whole soil and is not the same as texture, which refers to the fine-earth fraction. The fine-earth fraction consists of the particles that have a diameter <2 mm. Particle-size classes are a kind of compromise between engineering and pedologic classifications. The limit between sand and silt is a diameter of 74 microns in the engineering classification and of either 50 or 20 microns in pedologic classifications. The engineering classifications are based on percentages by weight in the fraction <74 mm in diameter, and textural classes are based on percentages by weight in the fraction <2 mm in diameter.

The very fine sand separate (diameter between 0.05 mm and 0.1 mm) is split in engineering classifications. In defining particle-size classes, much the same split is made but in a different manner. A fine sand or loamy fine sand normally has an appreciable content of very fine sand, but the very fine sand fraction is mostly coarser than 74 microns. A silty sediment, such as loess, may also have an appreciable component of very fine sand, but most of the very fine sand is finer than 74 microns. So, in particle-size classes, the very fine sand is allowed to "float." It is treated as sand if the texture is fine sand, loamy fine sand, or a coarser class. It is treated as silt if the texture is very fine sand, loamy very fine sand, sandy loam, silt loam, or a finer class.

No single set of particle-size classes seems appropriate as family differentiae for all kinds of soils. The classes that follow provide for a choice of either 7 or 11 particle-size classes. This choice permits relatively fine distinctions in soils if the particle size is important and broader groupings if the particle size is not susceptible to precise measurement or if the use of narrowly defined classes produces undesirable groupings. Thus in some families the term "clayey" indicates that there is 35 percent or more clay in defined horizons, but in other families the term "fine" indicates that the clay fraction constitutes 35 through 59 percent of the fine earth of the horizons, and the term "very-fine" indicates 60 percent or more clay. The term "rock fragments" refers to particles 2 mm in diameter or larger and includes all sizes that have horizontal dimensions less than the size of a pedon. It is not the same as coarse fragments, which excludes stones and boulders larger than about 25 cm. The term "fine earth" refers to particles smaller than 2 mm in diameter.

Definition of classes

Fragmental.—Stones, cobbles, gravel, and very coarse sand particles; too little fine earth to fill some of the interstices larger than 1 mm in diameter.

Sandy-skeletal.—Rock fragments 2 mm in diameter or larger make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is sandy as defined for the sandy particle-size class.

Loamy-skeletal.—Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

Clayey-skeletal.—Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is clayey as defined for the clayey particle-size class.

Sandy.—The texture of the fine earth is sand or loamy sand that contains less than 50 percent very fine sand; rock fragments make up less than 35 percent by volume.

Loamy[1].—The texture of the fine earth is loamy very fine sand, very fine sand, or finer, but the amount of clay is <35 percent; rock fragments are <35 percent by volume.

Coarse-loamy. By weight, 15 percent or more of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; <18 percent clay in the fine-earth fraction.

Fine-loamy. By weight, 15 percent or more of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction (<30 percent in Vertisols).

Coarse-silty. By weight, <15 percent of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; <18 percent clay in the fine-earth fraction.

Fine-silty. By weight, <15 percent of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction (<30 percent in Vertisols).

Clayey[1].—The fine earth contains 35 percent or more clay by weight, and rock fragments are <35 percent by volume.

Fine. A clayey particle-size class that has 35 through 59 percent clay in the fine-earth fraction (30 through 59 percent in Vertisols).

Very-fine. A clayey particle-size class that has 60 percent or more clay in the fine-earth fraction.

Modifiers that replace names of particle-size classes

There are three situations in which particle-size class names are not used. In one, the name is redundant. Psamments and Psammaquents, by definition, are sandy, and no particle-size class name is needed or used in the family name.

In the second situation, particle size is a meaningless concept because, presumably, the soil consists of a mixture of discrete mineral particles and of gels. The concept of either texture or particle size is not applicable to a gel, particularly if the gel cannot be dispersed. Consequently, no particle-size class names are used if the soil is mostly glass or if the exchange complex is dominated by amorphous materials, as is the situation with Andepts by definition. In families of Andepts and Andaquepts, in most andic subgroups of Inceptisols and andaqueptic and andeptic subgroups of other orders, and in families of Entisols and Aridisols with modifiers listed below, particle-size class names, as such, are not used for the part of the soil that does not disperse.

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In the third situation, the content of organic matter is high and particle size has only limited relation to the physical and chemical properties of the soils. This seems to be normal in soils that have both a cryic temperature regime and a spodic horizon. Therefore, particle-size class names are not used for the spodic horizons[2] of Cryaquods, Cryohumods, Cryorthods, or Cryic Placohumods.

The following terms are substituted for the particle-size class names in the taxa that have been listed unless the particle-size modifier is redundant. They reflect a combination of particle size and mineralogy, and they take the place of both.

Cindery.—Sixty percent or more of the whole soil (by weight)[3] volcanic ash, cinders, and pumice; 35 percent or more (by volume) is cinders that have diameter of 2 mm or more.

Ashy and ashy-skeletal.—These are mainly soils that have a fine-earth fraction that feels like a sand or a loamy sand after prolonged rubbing.

Ashy. Sixty percent or more of the whole soil (by weight) volcanic ash, cinders, and pumice; <35 percent (by volume) is 2 mm in diameter or larger.

Ashy-skeletal. Rock fragments other than cinders are 35 percent or more (by volume); the fine-earth fraction is otherwise ashy.

Medial and medial-skeletal.—These are soils that have a fine-earth fraction that feels loamy, as the term is defined earlier in this chapter, after prolonged rubbing.

Medial. Less than 60 percent of the whole soil (by weight) volcanic ash, cinders, and pumice; <35 percent (by volume) is 2 mm in diameter or larger; the fine-earth fraction is not thixotropic; the exchange complex is dominated by amorphous materials.

Medial-skeletal. Thirty-five percent (by volume) or more rock fragments other than cinders 2 mm in diameter or larger; the fine-earth fraction is otherwise medial.

Thixotropic and thixotropic-skeletal.—These are soils that have a fine-earth fraction that is thixotropic and an exchange complex dominated by amophous clays.

Thixotropic. Less than 35 percent (by volume) has diameter of 2 mm or larger; the fine-earth fraction is thixo-

tropic; the exchange complex is dominated by amorphous materials.

Thixotropic-skeletal. Thirty-five percent or more (by volume) rock fragments other than cinders 2 mm in diameter or larger; the fine-earth fraction is thixotropic.

Control section for particle-size classes or their substitutes

Names of particle-size classes or their substitutes as defined are not applied to a fragipan, duripan, or petrocalcic horizon but are applied to specific horizons or to the materials between given limits of depth that are defined in terms of either the distance below the surface of the mineral soil or the upper boundary of a specified horizon. The vertical section so defined is called the control section. Definitions of the control section for determination of the particle-size classes are arranged as a key.

A. Particle-size modifiers or substitutes are used to describe material from the surface to a lithic or paralithic contact, or to a fragipan, duripan, or petrocalcic horizon if any of these come within a depth of 36 cm (14 in.) or less; or to a depth of 36 cm if the soil temperature is 0° C or lower within this depth about 2 months after the summer solstice.

B. In other soils that do not have an argillic horizon or a natric horizon and in great groups of Spodosols, Alfisols, and Ultisols that have a spodic horizon or a fragipan in or above an argillic horizon:

> **1.** Particle-size modifiers or substitutes are used to describe material from the base of the Ap horizon or from a depth of 25 cm, whichever is greater, to a lithic or paralithic contact, fagipan, duripan, or petrocalcic horizon if the depth of any of these is <1 m; or to a depth 25 cm below the level at which the soil temperature is 0° C about 2 months after the summer solstice; whichever is shallower.
>
> **2.** Otherwise, particle-size modifiers or substitutes are used to describe material from a depth of 25 cm to a depth of 1 m.

C. In other soils of the orders Alfisols and Ultisols and in great groups of Aridisols and Mollisols that have an argillic horizon that has (a) a lower boundary deeper than 25 cm (see E) and (b) an upper boundary shallower than 1 m, or the soil is in a grossarenic subgroup:

> **1.** If there are no strongly contrasting particle-size classes, as defined later, and there is no fragipan, duripan, or petrocalcic horizon between the top of the argillic or natric horizon and a depth of 1 m, particle-size modifiers or substitutes are used to describe the whole argillic or natric horizon if it is <50 cm thick[4] or the upper 50 cm of the argillic or natric horizon if it is >50 cm thick.
>
> **2.** If there are horizons or layers of strongly contrasting particle-size classes, as defined later, within or below the argillic or natric horizon and within a depth of 1 m, particle-size modifiers or substitutes are used to describe material from the top of the argillic or natric

horizon to a depth of 1 m or to a lithic or paralithic contact, duripan, fragipan, or petrocalcic horizon, whichever is shallower.

3. If there is a fragipan, duripan, or petrocalcic horizon below an argillic or natric horizon, particle-size modifiers or substitutes are used to describe material from the top of the argillic horizon, excluding any part incorporated in an Ap horizon, to the top of the fragipan, duripan, or petrocalcic horizon, or are used to describe the upper 50 cm of the argillic or natric horizon whichever of these is less.

D. In other soils in the orders Alfisols and Ultisols and in great groups of Aridisols and Mollisols that have an argillic or natric horizon that has its upper boundary at a depth >1 m and that are not in a grossarenic subgroup, particle-size modifiers or substitutes are applied to describe material from a depth of 25 cm to a depth of 1 m below the mineral surface.

E. In other soils in which the lower boundary of the argillic or natric horizon is shallower than 25 cm, that is, they have a *ca* horizon in which there is soft powdery lime, or have a calcic or other named diagnostic horizon that has its upper boundary within 25 cm of the surface, or have rock structure dominant within that depth, particle-size classes are used to describe material from the top of the argillic horizon or the base of an Ap horizon, whichever is shallower, to a lithic or paralithic contact, a petrocalcic or petrogypsic horizon, duripan, or to a depth of 1 m, whichever is shallowest.

Strongly contrasting particle-size classes

In applying names of particle-size classes, the weighted average particle-size class of the control section or of the horizon listed is named unless there are strongly contrasting particle-size classes within the control section or the horizons. If there are strongly contrasting particle-size classes, both particle-size classes are named. Thus, if the weighted average of the upper part of the control section is loamy fine sand and the lower part is clay, the family differentia is sandy over clayey. If there are more than two contrasting particle-size classes within the control section, the classes differing most in median particle size are named. Sandy includes fine sand as well as coarser sands. Medial, ashy, or thixotropic substitutes are applied only if the materials extend at least 10 cm into the upper part of the control section.

The following particle-size classes are strongly contrasting if the transition between them is less than 12.5 cm thick:

1. Cindery over sandy or sandy-skeletal.
2. Cindery over loamy.
3. Sandy-skeketal over loamy if the loamy material has <50 percent fine or coarser sand.
4. Sandy over loamy if the loamy material has <50 percent fine or coarser sand.
5. Sandy over clayey.
6. Ashy over cindery.

7. Ashy over loamy-skeletal.
8. Ashy over loamy.
9. Loamy-skeletal over fragmental.
10. Loamy-skeletal over sandy.
11. Loamy-skeletal over clayey if there is an absolute difference of >25 percent in the percentages of clay in the fine-earth fractions.
12. Clayey-skeletal over sandy.
13. Medial over fragmental.
14. Medial over cindery.
15. Medial over sandy or sandy-skeletal.
16. Medial over loamy-skeletal.
17. Medial over loamy.
18. Medial over clayey.
19. Medial over thixotropic.
20. Coarse-loamy over fragmental.
21. Coarse-loamy over sandy or sandy-skeletal if the coarse-loamy material has <50 percent fine or coarser sand.
22. Loamy over sandy or sandy-skeletal if the loamy material has <50 percent fine or coarser sand.
23. Coarse-loamy over clayey.
24. Coarse-silty over sandy or sandy-skeletal.
25. Coarse-silty over clayey.
26. Fine-loamy over fragmental.
27. Fine-loamy over sandy or sandy-skeletal.
28. Fine-loamy over clayey if there is an absolute difference of >25 percent in the percentage of clay.
29. Fine-loamy over cindery.
30. Fine-silty over fragmental.
31. Fine-silty over sandy or sandy-skeletal.
32. Fine-silty over clayey if there is an absolute difference of >25 percent in the percentages of clay.
33. Clayey over fragmental.
34. Clayey over sandy or sandy-skeletal.
35. Clayey over loamy-skeletal if there is an absolute difference of >25 percent in the percentages of clay in the fine-earth fraction.
36. Clayey over loamy if there is an absolute difference of >25 percent in the percentages of clay.
37. Clayey over fine-silty if there is an absolute difference of >25 percent in the percentages of clay.
38. Thixotropic over fragmental.
39. Thixotropic over sandy or sandy-skeletal.
40. Thixotropic over loamy-skeletal.
41. Thixotropic over loamy.
42. Cindery over medial.
43. Cindery over medial-skeletal.
44. Ashy over medial.

The intent in setting up classes of strongly contrasting particle sizes is to identify changes in pore-size distribution that seriously affect movement and retention of water and that have not been identified in higher categories. The list given is intended for use in grouping the soil series of the United States into families. It is not intended as a complete list. For example, fine sand over coarse sand is common in

the Udipsamments of western Europe but is not known to be important in the United States.

Choice of 7 or 11 particle-size classes

Only the seven particle-size classes are used in lithic, arenic, and grossarenic subgroups and in shallow families.

In families of Ultisols and Oxisols not included in the preceding item, subclasses of loamy particle-size classes are used but not subclasses of the clayey classes.

If only a part of the control section of a soil in an andic or andeptic subggroup or other group where substitute terms are used is cindery, ashy, medial, or thixotropic, contrasting families are recognized, but only the seven particle-size classes are used. For example, we might use cindery over loamy but not cindery over fineloamy.

Only two particle-size classes are used to separate families in Vertisols, fine if there is <60 percent clay and very-fine if there is 60 percent or more clay in the weighted average of the control section.

Mineralogy classes

The control section

Mineralogy classes are based on the approximate mineralogical composition of selected size fractions of the same segment of the soil (control section) that is used for application of particle-size classes.

Contrasting mineralogy modifiers

Contrasting mineralogy modifiers are not recognized except where substitutes for particle-size class modifiers have been used. In those soils there is an overlay of ash or cinders, or an upper medial or thixotropic layer, and the ashy, cindery, medial, or thixotropic layer extends at least 10 cm into the upper part of the control section. In identifying and naming the contrasting mineralogy modifiers in families of those soils, the seven particle-size classes are used to describe the lower part of the section. For example, a pair of contrasting layers is named as medial over loamy, mixed, not medial over coarse-loamy, mixed.

If there are layers of contrasting particle size in the control section, the mineralogy class of the upper part of the control section is definitive of the family mineralogy. For example, if there is fine-loamy material of mixed mineralogy over sandy material that is siliceous, the proper modifiers to describe the family are fine-loamy over sandy, mixed, not fine-loamy, mixed, over sandy, siliceous.

Key to mineralogy classes

Mineral soils are placed in the first mineralogy class of the key (table 1) that accommodates them although they may appear also to meet the requirements of other mineralogy classes. This is a key, not a set of complete definitions. Subsititute terms connoting both particle size and mineralogy are based on combined texture, consistence,

and mineralogy classes and are used to indicate important variations in Andaquepts, Andepts, andic, andaqueptic, and andeptic subgroups, in cryic great groups and cryic subgroups of Spodosols, and in cindery and ashy families of Aridisols and Entisols. Mineralogy classes are not named in Calciaquolls because the effect of the carbonates overshadows other differences in mineralogy, and they are not named in Quartzipsamments, which, by definition, are siliceous.

It is recognized that it is normally impossible to be certain of the percentages of the various kinds of clay minerals. Quantitative methods of identification are still subject to change. Although much progress has been made in the past few decades, an element of judgment enters into the estimation. All the evidence does not need to come from X-ray, surface, and DTA determinations. Other physical and chemical properties suggest the mineralogy of many clayey soils. Changes in volume, cation-exchange capacity, and the consistence are useful in estimating the nature of clay.

The description of clay mineralogy in naming families of clayey soils is based on the weighted average of the control section.

Calcareous and reaction classes

The presence or absence of carbonates and the reaction are treated together because they are so intimately related. A calcareous horizon cannot be strongly acid. Calcareous classes are applied to the section between a depth of 25 and 50 cm or between a depth of 25 cm and a lithic or paralithic contact that is below a depth of 25 but not 50 cm, or to some part of the soil above a lithic or paralithic contact that is shallower than 25 cm. Two classes, calcareous and noncalcareous, are used in selected taxa. The definitions follow.

Calcareous.—The fine-earth fraction effervesces in all parts with cold dilute HCl.

Noncalcareous.—The fine-earth fraction does not effervesce in all parts with cold dilute HCl. The term noncalcareous is not used as a part of a family name.

It should be noted that a soil that contains dolomite is calcareous and that effervescence of dolomite, when treated with cold dilute HCl, is slow.

Reaction classes are applied to the control section that is defined for particle-size classes. Two classes, acid and nonacid, are used in selected taxa. The definitions follow.

Acid.—The pH is <5.0 in 0.01 M $CaCl_2$ (2:1) throughout the control section (about 5.5 in H_2O, 1:1).

Nonacid.—The pH is 5.0 or more in 0.01 M $CaCl_2$ (2:1) in at least some part of the control section. The term nonacid is not used in the family name of calcareous soils.

Reaction classes are used only in names of families of Entisols and Aquepts; they are not used in sandy, sandy-skeletal, and fragmental families of these taxa, nor are they

used in Sulfaquepts and Fragiaquepts, or in families that have carbonatic or gypsic mineralogy.

Calcareous classes are used if appropriate in the same taxa as reaction classes and, in addition, are used in families of Aquolls except for Calciaquolls and and for Aquolls that have an argillic horizon. Calcareous and reaction classes are not used in soils that have carbonatic or gypsic mineralogy. A soil that is calcareous is never acid. Calcareous therefore implies nonacid, and both names are not used because nonacid would be redundant. Similarly, noncalcareous would be redundant in acid families, and it is not used as part of the family name. If calcareous is used in a family name, calcareous is considered to be a subclass of mineralogy. It follows the mineralogy class name and is shown in parenthesis, for example: fine-loamy, mixed (calcareous), mesic Typic Haplaquolls.

Soil temperature classes

Soil temperature classes, as named and defined here, are used as family differentiae in all orders. The names are used as family modifiers unless the name of a higher taxon carries the same limitation. Thus, frigid is implied in all boric suborders and cryic great groups, and is redundant if used in the name of a family.

The Celsius (centigrade) scale is the standard. Approximate Fahrenheit equivalents are indicated parenthetically. It is assumed that the temperature is that of a soil that is not being irrigated.

For soils in which the difference is 5° C (9° F) or more between mean summer (June, July, and August in the northern hemisphere) and mean winter (December, January, and February in the northern hemisphere) soil temperature at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, the classes, defined in terms of the mean annual soil temperature, are as follows:

Frigid.—Below 8° C (47° F).

Mesic.—From 8° to 15° C (47° to 59° F).

Thermic.—From 15° to 22° C (59° to 72° F).

Hyperthermic.—22° C (72° F) or higher.

For soils in which the difference is less than 5° C (9° F) between mean summer and mean winter soil temperature at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, the classes, defined in terms of the mean annual soil temperature, are as follows:

Isofrigid.—Below 8° C (47° F).

Isomesic.—From 8° to 15° C (47° to 59° F).

Isothermic.—From 15° to 22° C (59° to 72° F).

Isohyperthermic.—22° C (72° F) or higher.

The appropriate limit between isofrigid and isomesic cannot be tested in the United States and probably will need to be revised.

Other characteristics

Several soil characteristics other than those already mentioned are needed in particular taxa to provide reasonable groupings of series into families. Some of these seem to be logical family criteria. Others probably should have been used in higher categories, but the lack of information about them makes it much safer to use them as family differentiae at this time. These characteristics include depth of soil, consistence, moisture equivalent, slope of soil, and permanent cracks.

Depth of soil

Classes of shallow and deep soils may be needed at the family level in all the orders of mineral soils. Some distinctions in depth are made in great groups and in arenic, paralithic, and lithic subgroups, but some other soils should also be grouped in families according to depth. Some soils have a paralithic contact over soft rock such as clay shale that is too compact for penetration by roots. The soil depth classes follow:

Micro.—Less than 18 cm through diagnostic horizons. Used in cryic great groups but not in pergelic subgroups or in Entisols.

Shallow.—Two depths are considered shallow.

a. Less than 50 cm to the upper boundary of a duripan or a petrocalcic horizon or to a paralithic or a petroferric contact. Used in all great groups of Entisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, and Ultisols, except pergelic subgroups of the cryic great groups (Cryaquepts, Cryumbrepts, Cryorthods, and so on). Note that lithic and paralithic subgroups are also shallow, but the adjective "shallow" in a family name of them is redundant.

b. Less than 1 m to a lithic or paralithic or a petroferric contact. Used in families of Oxisols.

Consistence

Some cemented horizons, for example, a duripan, are differentiae in the classification in categories above the family. Others such as a cemented spodic horizon (ortstein) are not, but no single family should include soils that have a continuous, shallow, cemented horizon and soils that do not. In Spodosols, in particular, a cemented spodic horizon needs to be used as a family differentia. The following classes of consistence are defined for Spodosols.

Ortstein.—All or part of the spodic horizon is at least weakly cemented, when moist, into a massive horizon that is present in more than half of each pedon.

Noncemented.—The spodic horizon, when moist, is not cemented into a massive horizon in as much as half of each pedon.

Cementation of a small volume into shot or concretions does not constitute cementation to form a massive horizon. The name of a family of noncemented Spodosols normally does not have a modifier to imply lack of cementation. The name of a family of cemented Spodosols contains the modifier "ortstein."

A cemented calcic or gypsic horizon is not identified in the family name. Many calcic and some gypsic horizons are weakly cemented and some are indurated. The recognition of a petrocalcic or petrogypsic horizon is expected to meet most, if not all, the needs for recognition of cementation in those horizons. Taxa of these cemented soils are not named in the family category.

Classes of coatings (on sands)

Despite the empahsis given to particle-size classes in the taxonomy, variability remains in the sandy particle-size class, which takes in sands and loamy sands. Some sands are very clean, almost completely free of silt and clay. Others are mixed with appreciable amounts of finer grains. A moisture equivalent of 2 percent makes a reasonable division of the sands at the family level. Two classes of Quartzipsamments are defined in terms of their moisture equivalent.

Coated.—The moisture equivalent is 2 percent or more.

Uncoated.—The moisture equivalent is <2 percent. The moisture retained at tension of 0.5 bar may be subsituted for the moisture equivalent. Or, if moisture tension data are not available, the silt plus clay is ≤5 percent.

The moisture equivalent for this distinction is the weighted average for the control section, weighted for the thickness of each horizon or layer.

Slope or shape of soil

Soils of aquic great groups normally have level or concave surfaces. They are mainly in places where ground water saturates the soil during some period of the year. A few, however, are on the sides of slopes where water cannot stand and are kept wet by more or less continuous precipitation and by seepage of water from higher areas. In a very few, the hydrostatic pressure keeps the soil wet. No consistent internal morphologic clues have yet been found that distinguish these sloping aquic soils if the dissolved oxygen content is low, but their recognition in the field from the position of the soil in the landscape is generally easy. It is proposed, therefore, in aquic great groups, particularly in Aquolls and Aquults, to use the shape of the soil as a family differentia. Classes of level and sloping soils seem adequate, as these classes are defined in the Soil Survey Manual (Soil Survey Staff 1951). It may be necessary to use slope classes as family differentiae in other orders, but they should not be used in families of Aquods or Albaqualfs. Level is assumed in families of aquic soils if no slope modifier is used in the family name.

Classes of permanent cracks

Hydraquents consolidate[5] after drainage and become Fluvaquents. In the process, they form polyhedrons, roughly 12 to 50 cm in diameter, depending on the *n*- value and particle size. The polyhedrons are separated by cracks that range in width from 2 mm to >1 cm. The polyhedrons may shrink and swell with changes in moisture content of the

soil, but the cracks are permanent and can persist for some hundreds of years even though the soils are cultivated. The cracks permit rapid movement of water through the soil either vertically or laterally. Yet the soils may have the same particle size, mineralogy, and other family properties as soils that are not cracked or that have cracks that open and close with the seasons. The soils that have permanent cracks are so rare in the United States that only a provisional definition of their characteristics can be presented.

The modifier "cracked" is used only to designate families of Fluvaquents. It means that there are continuous, permanent, lateral and vertical cracks, at least 2 mm wide, spaced at average lateral intervals of 50 cm or less. If this modifier is not in the family name, permanent cracks are assumed to be absent.

Family differentiae for Histosols

Most of the differentiae used to distinguish families of Histosols have been defined earlier, either because they are differentiae in mineral soils as well as in Histosols; or because their definitions are essential for the classification of some Histosols in categories higher than the family. The differntiae that are not defined elsewhere are defined in this section and the taxa in which they are used are enumerated.

The order in which family modifiers are placed in the technical family names of Histosols follows. The modifiers chosen are those appropriate to the particular family.

Particle size
Mineralogy, including nature of limnic deposits
Reaction
Soil temperature regime
Soil depth

The differentiae are discussed in the remainder of this section.

Particle-size classes

Particle-size modifiers are used in family names of Histosols only in terric subgroups. The terms used follow.

Fragmental
Loamy-skeletal or clayey-skeletal
Sandy or sandy-skeletal
Loamy
Clayey

The meaning of each of these terms is the same as that defined for particle-size classes of mineral soils. The proper term is selected to describe the weighted average particle size of the upper 30 cm of the mineral layer or that part of the mineral layer that is within the control section, whichever is thicker.

Mineralogy classes

Mineraolgy classes of Histosols are of three kinds, according to the nature of the subgroup or great group.

Ferrihumic.—Containing ferrihumic materials within the control section (applied to Fibrists, Hemists, and Saprists, except Sphagnofibrists and sphagnic subgroups of other great groups). Bog iron is present in some Histosols or in organic soil materials. It is called ferrihumic material. It consists of authigenic deposits (formed in place) of hydrated iron oxides mixed with varying kinds or amounts of organic materials. The iron in some places is present in large cemented aggregates. In others it may be mostly dispersed and soft. The colors normally are shades of dark reddish brown, commonly mixed with black, and the colors change little on drying. The content of iron oxide ranges from 10 percent to >20 percent.

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Ferrihumic material either is saturated with water for long periods (>6 months) or is in an artificially drained soil. The content of free iron oxide should exceed 10 percent (7 percent Fe), but the horizon may be either organic or mineral provided there is at least 1 percent organic matter. The materials should have >2 percent (by weight) concretions of iron, which may range in size from fine (<5 mm) to 1 m or more in the largest lateral dimension. Colors should be dark reddish brown or reddish brown, or should be close to those colors. The presence of ferrihumic material within the control section is one of the family differentiae.

If ferrihumic is used as a modifier in the technical family name, no other mineralogy modifier is used because the presence of the iron is considered to be, by far, the most important characteristic.

Modifiers applied only to terric subgroups.—The mineralogy modifiers used for mineral soils are applied to the mineral parts of the soil for which a particle-size modifier has been used if the mineralogy is not ferrihumic.

Modifiers applied to limnic subgroups.—If limnic materials are present in the control section, if they are 5 cm or more thick, and if the materials do not have ferrihumic mineralogy, the following modifiers are used.

Coprogenous. Limnic materials that consist of coprogenous earth are present.

Diatomaceous. Limnic materials that consist of diatomaceous earth are present.

Marly. Limnic naterials that consist of marl are present.

Reaction classes

Modifiers to indicate reaction are used in all subgroups. The meanings follow.

Euic.—The pH of undried samples is 4.5 or more (0.01 M $CaCl_2$) in at least some part of the organic materials in the control section.

Dysic.—The pH is <4.5 (in 0.01 M $CaCl_2$) in all parts of the organic materials in the control section.

Soil temperature classes

Names and definitions of classes follow the rules given for soil temperature classes of mineral soils. Frigid, however, is redundant in boric and cryic great groups and is not used. No temperature modifier is used in pergelic subgroups.

Soil depth classes

Soil depth modifiers are used in all lithic subgroups of Histosols except in the suborder of Folists. It is assumed that lithic Folists have a shallow lithic contact. Other lithic Histosols have a lithic contact within the control section but it may be as much as 160 cm deep.

Shallow families.—Used in lithic subgroups to indicate a lithic contact between a depth of 18 cm and 50 cm.

Micro families.—Used to indicate a lithic contact shallower than 18 cm without regard to soil temperature. (In mineral soils, micro families are restricted to cryic great groups.)

[1] If the ratio of 15-bar water to clay is 0.6 or more in half or more of the control section, the percentage of clay is considered to be 2.5 times the percentage of 15-bar water. Carbonates of clay size are not considered to be clay but are treated as silt in all particlesize classes.

[2] Particle-size class names are applied to other spodic horizons but with reservations. Somewhat different classes probably should be used for most families of Spodosols, but data are too few to permit the testing of alternatives. Some series that would otherwise be reasonable homogeneous are split at the family level by the particle-size classes. These soils have appreciable but not very large amounts of organic matter in the spodic horizon.

[3] Percentages by weight in these definitions are estimated from grain counts; usually, a count of one or two dominant size fractions of the conventional mechanical analysis is enough for placement of the soil.

[4] The upper boundary of the argillic horizon is not always obvious. If properties of an argillic horizon are present but the upper boundary is gradual, use the depth at which the percentage of clay exceeds that of a higher lying horizon by the appropriate amount after fitting to a smooth curve. If the boundary is irregular or broken, as in A&B or B&A horizons, use the depth at which half or more of the volume has the fabric of an argillic horizon.

[5] The process is designated by a Dutch word that means "to ripen" because the change resembles the change in consistence of cheese as water is removed.

TABLE 1—*Key to mineralogy classes*

Class	Definition	Determinant size fraction
	CLASSES APPLIED TO SOILS OF ANY PARTICLE-SIZE CLASS	
Carbonatic	More than 40 percent by weight carbonates (expressed as $CaCO_3$) plus gypsum, and the carbonates are >65 percent of the sum of carbonates and gypsum.	Whole soil, particles <2 mm in diameter or whole soil <20 mm, whichever has higher percentage of carbonates plus gypsum.
Ferritic	More than 40 percent by weight iron ioxide extractable by citrate-dithionite, reported as Fe_2O_3 (or 28 percent reported as Fe).	Whole soil, particles <2 mm in diameter.
Gibbsitic	More than 40 percent by weight hydrated aluminum oxides, reported as gibbsite and bohemite.	Whole soils, particles <2 mm in diameter.
Oxidic	Less than 90 percent quartz: <40 percent any other single mineral listed subsequently; and the ratio, percent extractable iron oxide plus percent gibbsite to percent clay,[1] is 0.20 or more. That is, $\frac{\text{extractable } Fe_2O_3\text{(pct.)} + \text{gibbsite (pct.)}}{\text{clay (pct.)}^1} \geq 0.2$	For quartz and other minerals, fraction 0.02 to 2 mm in diameter; for ratio of iron oxide and gibbsite to clay, whole soil <2 mm.
Serpentinitic	More than 40 percent by weight serpentine minerals (antigorite, chrysotile, fibrolite, and talc).	Whole soil, particles <2 mm in diameter.
Gypsic	More than 40 percent by weight of carbonates (expressed as $CaCO_3$) plus gypsum, and the gypsum is >35 percent of the sum of carbonates and gypsum.	Whole soil, particles <2 mm in diameter, or whole soil <20 mm, whichever has higher percentage of carbonates plus gypsum.
Glauconitic	More than 40 percent glauconite by weight.	Whole soil, particles <2 mm in diameter.
	CLASSES APPLIED TO SOILS THAT HAVE A FRAGMENTAL, SANDY, SANDY-SKELETAL, LOAMY, OR LOAMY-SKELETAL PARTICLE-SIZE CLASS	
Micaceous	More than 40 percent mica by weight.[2]	0.02 to 20 mm.
Siliceous	More than 90 percent by weight[2] of silica minerals (quartz, chalcedony, or opal) and other extremely durable minerals that are resistant to weathering.	0.02 to 2 mm.
Mixed	All others that have <40 percent of any one mineral other than quartz or feldspars.	0.02 to 2 mm.
	CLASSES APPLIED TO SOILS THAT HAVE A CLAYEY OR CLAYEY-SKELETAL PARTICLE-SIZE CLASS	
Halloysitic	More than half halloysite[3] by weight and smaller amounts of allophane or kaolinite or both.	<0.002 mm.
Kaolinitic	More than half kaolinite, tabular halloysite, dickite, and nacrite by weight, smaller amounts of other 1:1 or nonexpanding 2:1 layer minerals or gibbsite, and <10 percent montmorillonite.	<0.002 mm.
Montmorillonitic	More than half montmorillonite and nontronite by weight or a mixture that has more montmorillonite than any other one clay mineral.	<0.002 mm.
Illitic	More than half illite (hydrous mica) by weight and commonly >4 percent K_2O.	<0.002 mm.
Vermiculitic	More than half vermiculite by weight or more vermiculite than any other one clay mineral.	<0.002 mm.
Chloritic	More than half chlorite by weight or more chlorite than any other clay mineral.	<0.002 mm.
Mixed	Other soils.[4]	<0.002 mm.

[1]Percentage of clay or percentage of 15-bar water times 2.5, whichever is greater, provided the ratio of 15-bar water to clay is 0.6 or more in half or more of the control section.

[2]Percentages by weight are estimated from grain counts. Usually, a count of one or two of the dominant size fractions of a conventional mechanical analysis is sufficient for placement of the soil.

[3]Halloysite as used here includes only the tubular forms. What has been called tabular halloysite is grouped here with kaolinite.

[4]Sepiolitic, defined as containing more than half by weight of sepiolite, attapulgite, and palygorskite, should be named if found.

TABLE 2—*Use of Soil Family Criteria and Control Sections*

Feature	Alfisols	Aridisols	Entisols	Histosols	Inceptisols
Particle-size[1]	Upper 50 cm of Bt or whole Bt if <50 cm thick[3]. If Bt is >1 m deep and not in upper boundary of grossarenic subgroup, 25 cm to 1 m. 11 classes, except in lithic, andeptic, and arenic subgroups, and shallow families, where 7 classes are used.	Upper 50 cm of Bt or whole Bt if <50 cm thick[3] If without Bt, 25 cm to 1 m. 11 classes, except in lithic subgroups and shallow families, where 7 classes are used.	25 cm to 1 m, but not used in Psamments or Psammaquents 11 classes except in lithic subgroups and shallow families where 7 classes are used.	Only in Terric subgroups; the thicker of upper 30 cm of mineral layer or within control section. 5 classes	25 cm to 1 m except in Andepts and Andaquepts. 11 classes used except in lithic and Andic subgroups and shallow families where 7 classes are used.
Mineralogy	Same as particle-size classes. If contrasting classes are present, only the upper materials.	Same as particle-size classes. If contrasting classes are present, only the upper materials.	Not used in Quartzipsamments, but used in other Psamments and all other great groups with same depth limits as particle-size classes. If contrasting classes are present, only the upper materials.	Same as particle-size classes[4] and in limnic subgroups.	Same as particle-size classes; if contrasting, only upper materials; in Andic subgroups, used in lower part of control section.
Combination of particle-size and mineralogy	Not used.	Ashy or cindery used if relevant.	Ashy or cindery used if relevant.	Not used except in Terric subgroups.	In Andepts, Andaquepts and Andic subgroups.
Calcareous and reaction classes	Not used.	Used in Paleargids, Haplargids, and Camborthids. Acid families are named but nonacid and calcareous families are not distinguished. Control section same as for particle-size.	Calcareous classes 25 to 50 cm, or some part of some soil above lithic or paralithic contact shallower than 25 cm. Not used in sandy, sandy-skeletal or fragmental families or with carbonatic or gypsic mineralogy or Sulfaquents. Reaction classes same control section as for particle-size.	Euic and Dysic classes for whole control section.	Used only in Aquepts other than Fragiaquepts. Calcareous classes, 25 to 50 cm. Reaction classes, 25 cm to 1 m.
Soil temperature	Not used in Cryic great groups or Boralfs.	Used in all families, except of Borollic subgroups.	Not used in Cryic great groups.	Not used in Cryic or Boric great groups.	Not used in Cryic great groups.
Depth[2]	Micro, used in Cryic great groups but not in pergelic subgroups. Shallow, not used in pergelic subgroups or lithic subgroups. Used in all others.	Micro and shallow used in all subgroups but lithic.	Micro not used. Shallow used in all subgroups except lithic and pergelic.	Micro, in all lithic subgroups except Folists for lithic contact <18 cm. Shallow in lithic subgroups except in Folists for lithic contact 18–50 cm deep.	Not used in pergelic subgroups.
Slope	Not used.	Not used.	Not used.	Not used.	Not used.
Consistence	Not used.	Not used.	Not used.	Not used.	Not used.
Moisture equivalent	Not used.	Not used.	Used only in Quartzipsamments.	Not used.	Not used.
Cracks	Not used.	Not used.	Used only in Fluvaquents.	Not used.	Not used.

[1]Control section for particle-size classes never includes rock, petrocalcic horizons, duripans, fragipans or permafrost zones (25 cm below frost 2 months after summer solstice). If any of these are within 36 cm of the soil surface, the control section is from the surface to the listed feature.

[2]Depth to paralithic contact, duripan, petrocalcic horizon or petroferric contact. Shallow is never used in lithic subgroups or mineral soils; otherwise refers to depth to listed features at <50 cm unless noted. Micro refers to base of diagnostic horizons at depths <18 cm.

[3]If base of Bt is <25 cm, from top of Bt or base of Ap to 1 m.

[4]Some additional mineral classes are used only for Histosols. See text of *Soil Taxonomy*, p. 389.

TABLE 2—*(Continued)*

Mollisols	Oxisols	Spodosols	Ultisols	Vertisols
Upper 50 cm of Bt or whole Bt if <50 cm thick[3].	25 cm to 1 m.	25 cm to 1 m; not used for spodic horizons of Cryic great groups or Cryic subgroups[5].	Upper 50 cm of Bt or whole Bt if <50 cm thick[3]. If upper boundary of Bt is >1 m deep and not in grossarenic subgroup, 25 cm to 1 m.	25 cm to 1 m. Fine 30-60 percent clay. Very fine 60 percent clay.
If without Bt, 25 cm to 1 m.				
11 classes except in lithic, andic, or arenic subgroups or shallow families where 7 classes are used.	Subclasses of loamy families but not of clayey families; all other classes are used.	7 classes in lithic, arenic, and grossarenic subgroups and shallow families, 11 classes in all others.	Subclasses of loamy classes but not of clayey classes, and all other classes. Only 7 classes in lithic, andic, or arenic subgroups or shallow families.	
Same as particle-size classes; if contrasting classes, only upper materials; in Andeptic subgroups, used for lower materials.	Same as particle-size classes.	Same as particle-size classes. If contrasting classes, only used for upper materials.	Same as particle-size classes. If contrasting classes, use upper materials.	Same as particle-size classes.
In Andeptic subgroups.	Not used.	Used for spodic horizons of Cryic great groups and Cryic subgroups[5].	Not used.	Not used.
Calcareous classes used in all Aquolls except Calciaquolls and Argiaquolls between 25 and 50 cm depth; not used with carbonatic or gypsic mineralogy.	Not used.	Not used.	Not used.	Not used.
Not used in Cryic great groups or Borolls.	Used in all families.	Not used in Cryic great groups or Cryic subgroups.	Used in all families.	Used in all families.
Not used in pergelic subgroups or lithic subgroups.	Shallow, <1 m to lithic or petroferric contact.	Not used in pergelic or lithic subgroups.	Used in all families.	Not used.
Used in Aquolls.	Not used.	Not used.	Not used.	Not used.
Not used.	Not used.	Used for cemented spodic horizons.	Not used.	Not used.
Not used.	Not used.	Not used.	Not used.	Not used.
Not used.	Not used.	Not used.	Not used.	Not used.

[3]If base of Bt is <25 cm, from top of Bt or base of Ap to 1 m.
[4]Some additional mineral classes are used only for Histosols. See text of *Soil Taxonomy*, p. 389.
[5]In the absence of rock or ice within 36 cm, the spodic horizon must extend below a depth of >25 cm before this applies.

Chapter 4
Identification of the Taxonomic Class of a Soil

Key to soil orders

In this key and the other keys that follow, the diagnostic horizons and the properties mentioned do not include the properties of buried soils except their organic carbon if of Holocene age and base saturation. Properties of buried soils are considered in the categories of subgroups, families, and series but not in those of order, suborder, and great group. The meaning of the term "buried soil" has been given previously.

ORD

A. Soils that

1. Have organic soil materials that extend from the suface to one of the following:

a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or

b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or

2. Have organic materials that have an upper boundary within 40 cm of the surface and

a. Have one of the following thicknesses:

(1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that

(1) Do not have a mineral layer as much as 40 cm thick either at the suface or whose upper boundary is within a depth of 40 cm from the surface; and

(2) Do not have mineral layers, taken cumulatively, as thick as 40 cm within the upper 80 cm.

Histosols, p. 127

B. Other soils that do not have a plaggen epipedon but that have

1. A spodic horizon whose upper boundary is within 2 m of the surface; or

2. A placic horizon that meets all the requirements of a spodic horizon except thickness and index of accumulation and rests on a fragipan, on a spodic horizon, or on an albic horizon that rests on a fragipan.

Spodosols, p. 213

C. Other soils that

1. Have an aquic moisture regime and have plinthite that forms a continuous phase within 30 cm of the surface of the mineral soil; or

2. Have an oxic horizon within 2 m of the soil surface but do not have a plaggen epipedon and do not have either an argillic or a natric horizon that overlies the oxic horizon.[1]

Oxisols, p. 203

D. Other soils that

1. Do not have a lithic or paralithic contact, petrocalcic horizon, or duripan within 50 cm of the surface; and

2. After the soil to a depth of 18 cm has been mixed, as by plowing, have 30 percent or more clay in all subhorizons to a depth of 50 cm or more; and

3. Have, at some time in most years unless irrigated or cultivated, open cracks[2] at a depth of 50 cm that are at least 1 cm wide and extend upward to the surface or to the base of the plow layer or surface crust; and

4. Have one or more of the following;

a. Gilgai;

b. At some depth between 25 cm and 1 m, slickensides close enough to intersect; or

c. At some depth between 25 cm and 1 m, wedge-shaped natural structural aggregates that have their long axes tilted 10° to 60° from the horizontal.

Vertisols, p. 241

E. Other soils that have an ochric or anthropic epipedon and either

1. Do not have an argillic or a natric horizon but

a. Are saturated with water within 1 m of the surface for 1 month or more in some years and have a salic horizon whose upper boundary is within 75 cm of the surface; or

b. Have one or more of the following horizons whose upper boundary is within 1 m of the soil surface: a petrocalcic, calcic, gypsic, petrogypsic, or cambic horizon or a duripan; and have an aridic moisture regime, or

2. Have an argillic or a natric horizon and have

a. An aridic moisture regime; and

b. An epipedon that is not both massive and hard or very hard when dry.

Aridisols, p. 91

F. Other soils that have a mesic, isomesic, or warmer temperature regime, do not have tongues of albic materials in the argillic horizon that have vertical dimensions of as much as 50 cm if there is >10 percent weatherable minerals in the 20- to 200-micron fraction, but have one of the following combinations of characteristics:

1. Have an argillic horizon but not a fragipan and have base saturation (by sum of cations) of <35 percent at the following depths:

a. If the argillic horizon has in some part a hue of 5YR or yellower, or a color value, moist, of 4 or more, or a color value, dry, that is more than 1 unit higher than the value, moist, the shallowest of the following:

(1) 1.25 m below the upper boundary of the argillic horizon;

(2) 1.8 m below the surface of the soil; or

(3) Immediately above a lithic or paralithic contact;

b. If the argillic horizon has some other color or if the epipedon has a sandy or sandy-skeletal particle-size class throughout, the deepest of 1.25 m below the upper boundary of the argillic horizon, 1.8 m below the surface of the soil, or immediately above a lithic or a paralithic contact if it is shallower;

2. Have a fragipan that

a. Meets all the requirements of an argillic horizon or has clay skins >1 mm thick in some part, or underlies an argillic horizon; and

b. Has base saturation (by sum of cations) of <35 percent at a depth of 75 cm below the upper boundary of the fragipan or immediately above a lithic or paralithic contact, whichever is shallower.

Ultisols, p. 223

G. Other soils that

1. Have either of the following:

a. A mollic epipedon; or

b. A surface horizon that, after the soil to a depth of 18 cm is mixed, meets all requirements of a mollic epipedon except thickness, and, in addition, have an upper subhorizon >7.5 cm thick that is in an argillic or a natric horizon, that meets the requirements of a mollic epipedon with respect to color, content of organic carbon, base saturation, and structure but is separated from the surface horizon by an albic horizon; and, in addition,

2. Have base saturation of 50 percent or more (by NH_4OAc) as follows:

a. If there is an argillic or a natric horizon, from its upper boundary to a depth of 1.25 m below that boundary, or to a depth 1.8 m below the soil surface or to a lithic or paralithic contact, whichever is least; or

b. If there is no argillic or natric horizon, in all subhorizons to a depth 1.8 m below the soil surface or to a lithic or paralithic contact, whichever is least; and

3. If the exchange complex is dominated by amorphous materials, have, in some subhorizon within a depth of 35 cm or to a lithic or paralithic contact shallower than 35 cm, a bulk density (at 1/3-bar water tension) of the fine-earth fraction of 0.85 or more and have <60 percent vitric volcanic ash,[3] cinders, or other pyroclastic material in the silt, sand, and gravel fractions within this depth;

Mollisols, p. 169

ORD

H. Other soils that

1. Have an argillic or natric horizon but no fragipan; or
2. Have a fragipan that
   a. Is in or underlies an argillic horizon; or
   b. Meets all requirements of an argillic horizon; or
   c. Has clay skins >1 mm thick in some part.

Alfisols, p. 61

I. Other soils that have no sulfidic material within 50 cm of the mineral soil surface; and have between 20 and 50 cm below the mineral soil surface an n value of 0.7 or less in one or more subhorizons or less than 8 percent clay in one or more subhorizons; and have one or more of the following:

1. An umbric, mollic, histic (either mineral or organic) or plaggen epipedon;
2. A cambic horizon or both an aquic moisture regime and permafrost;
3. Within 1 m of the surface, a calcic, petrocalcic, gypsic, petrogypsic, or placic horizon or a duripan;
4. A fragipan;
5. A sulfuric horizon whose upper boundary is within 50 cm of the soil surface; or
6. In half or more of the upper 50 cm, an SAR of ≥13[4] (or sodium saturation that is ≥15 percent) that decreases with depth below 50 cm and, within a depth of 1 m, have ground water at some period during the year when the soil is not frozen in any part.

Inceptisols, p. 141

J. Other soils.

Entisols, p. 107

[1] If an epipedon is more than 2 m thick but is immediately underlain by an oxic horizon, the soil is included in Oxisols.

[2] An open crack is interpreted to be a separation between gross polyhedrons. If the surface horizons are strongly self-mulching, that is, if the soil is a mass of loose granules, or if the soil is cultived while the cracks are open, the cracks may be largely filled with granular materials from the surface. But they are considered to be open in the sense that the polyhedrons are separated.

[3] Vitric material, as used here, includes glass and also crystalline particles that are coated with glass or with partly devitrified glass.

[4] The percentage of exchangeable sodium (ESP) is used in the definition of the natric horizon and in a number of the taxa. Since this text was written, the U.S. Salinity Laboratory (personâl communication from C.A. Bower) has revised its definition of sodic (alkali) soils and the method for measuring the sodium adsorption ratio (SAR) as follows: SAR is measured by the normal method if the conductivity (EC) of the saturation extract is 20 mmhos per cm at 25° C. If the conductivity is ≥20 mmhos and SAR is 10, SAR is determined on a sample that has been leached with distilled water until EC of the leachate decreases to about 4 mmhos per centimeter but not to 4. ESP of ≥15 is replaced by SAR of ≥13 if EC is large enough to require a correction for soluble salts in calculating ESP. If EC is low enough (≤4) that no correction is needed for soluble salts, ESP is determined directly from the replaced cations.

Chapter 5
Alfisols

ALF

Key to suborders

HA. Alfisols that have an aquic moisture regime or are artificially drained and that have characteristics associated with wetness, namely, mottles, or iron-manganese concretions >2 mm in diameter, or chroma of 2 or less immediately below any Ap horizon or below any dark A1 horizon in which the moist color value is less than 3.5 after the material is rubbed, and one of the following:

1. Dominant chroma of 2 or less[1] in coatings on the surface of peds and mottles within peds of the argillic horizon, or a dominant chroma of 2 or less in the matrix of the argillic horizon and mottles of higher chroma;

2. If there are no mottles in the argillic horizon, a dominant chroma of 1 or less.

Aqualfs, p. 61

HB. Other Alfisols that have

1. A frigid temperature regime but do not have a xeric moisture regime; or

2. A cryic temperature regime.

Boralfs, p. 67

HC. Other Alfisols that have one of the following:

1. An ustic moisture regime;

2. An epipedon that is both massive and hard or very hard when dry and a moisture regime that is aridic but marginal to ustic;

3. Within a depth of 1.5 m of the surface or within a depth of 50 cm below the base of the argillic horizon, a calcic horizon or soft powdery lime in spheroidal forms or as coatings on peds or disseminated in particles of clay size[2] and a moisture regime that is udic but marginal to ustic.

Ustalfs, p. 79

HD. Other Alfisols that have one of the following:

1. A xeric moisture regime; or

2. An epipedon that is both massive and hard or very hard when dry and a moisture regime that is aridic but marginal to xeric.

Xeralfs, p. 84

HE. Other Alfisols that have a udic moisture regime.

Udalfs, p. 71

AQUALFS

Key to great groups

HAA. Aqualfs that have plinthite that forms a continuous phase or constitutes half or more of the matrix within some subhorizon between 30 cm and 1.25 m below the surface of the soil.

Plinthaqualfs, p. 66

HAB. Other Aqualfs that have a natric horizon and do not have a duripan.

Natraqualfs, p. 64

HAC. Other Aqualfs that have a duripan.

Duraqualfs, p. 63

HAD. Other Aqualfs that have an isomesic or a warmer iso temperature regime.

Tropaqualfs, p. 66

HAE. Other Aqualfs that have a fragipan.

Fragiaqualfs, p. 63

HAF. Other Aqualfs that have an albic horizon tonguing into an argillic horizon.

Glossaqualfs, p. 63

HAG. Other Aqualfs that have an abrupt textural change between an ochric epipedon or an albic horizon and an argillic horizon and have slow or very slow hydraulic conductivity in the argillic horizon.[3]

Albaqualfs, p. 62

HAH. Other Aqualfs that have an umbric epipedon.

Umbraqualfs, p. 67

HAI. Other Aqualfs.

Ochraqualfs, p. 64

Albaqualfs

Distinctions between Typic Albaqualfs and other subgroups

Typic Albaqualfs are the Albaqualfs that

a. Have chroma of 2 or less in 60 percent or more of the mass between the bottom of the A1 or the Ap horizon and a depth of 75 cm;

b. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Do not have a horizon within a depth of 1 m from the surface that is brittle, that is 15 cm or more thick, and that contains some opal coatings or some (<20 percent) durinodes;

d. Either have an Ap horizon that has a color value, moist, of 4 or more, or a color value, dry, of 6 or more after the soil has been crushed and smoothed, or have, after the soil to a depth of 18 cm has been mixed, an upper layer that has these colors;

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and that extend upward to the surface or to the base of an Ap or an albic horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the soil to a depth of 1 m or in the whole soil if the depth to a lithic or paralithic contact is >50 cm but <1 m;

(3) More than 35 percent clay in horizons that have a total thickness of >50 cm;

f. Have texture that is very fine sand or finer in some subhorizon within a depth of 50 cm from the soil surface; and

g. Have a surface horizon that, after the soil to a depth of

18 cm has been mixed, has <30 percent clay and is continuous throughout each pedon.

Aeric Albaqualfs are like Typic Albaqualfs except for *a*.

Arenic Albaqualfs are like Typic Albaqualfs except for *f*, with or without *a* or *d* or both.

Mollic Albaqualfs are like Typic Albaqualfs except for *d*.

Ruptic-Vertic Albaqualfs are like Typic Albaqualfs except for *e* and *g* with or without *a* or *d*, or both.

Udollic Albaqualfs are like Typic Albaqualfs except for *a* and *d*.

Vertic Albaqualfs are like Typic Albaqualfs except for *e* with or without *a* or *d*, or both.

Duraqualfs

Duraqualfs are the Aqualfs that have a duripan below the argillic horizon. They are not known to occur in the United States. The group has been proposed for other countries, but definitions of subgroups have not been suggested.

ALF

Fragiaqualfs

Distinctions between Typic Fragiaqualfs and other subgroups

Typic Fragiaqualfs are the Fragiaqualfs that

a. Do not have a mottled horizon between the A1 or Ap horizon and a fragipan that has dominant chroma more than 2 if the hue is 10YR or redder or more than 3 if the hue is 2.5Y or yellower;

b. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m (60 in.) of the surface;

c. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the upper soil to a depth of 18 cm, after mixing, has these color values;

Aeric Fragiaqualfs are like Typic Fragiaqualfs except for *a*.

Umbric Fragiaqualfs are like Typic Fragiaqualfs except for *c*.

Glossaqualfs

Distinctions between Typic Glossaqualfs and other subgroups

Typic Glossaqualfs are the Glossaqualfs that

a. Have in 60 percent or more of the matrix[4] in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one of the following:

(1) If mottled and the value, moist, is 4 or more, the chroma, moist, is 2 or less;

(2) If not mottled, the chroma, moist, is 1 or less;

b. Have texture finer than loamy fine sand in some subhorizon within a depth of 50 cm below the surface; and

c. Have an Ap horizon that has either a color value, moist,

of 4 or more, or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the soil to a depth of 18 cm, after mixing, has these colors.

Aeric Glossaqualfs are like Typic Glossaqualfs except for *a* or for *a* and *c*.

Arenic Glossaqualfs are like Typic Glossaqualfs except for *b* or for *a* and *b;* they have a sandy epipedon between 50 cm and 1 m thick.

Mollic Glossaqualfs are like Typic Glossaqualfs except for *c*.

Natraqualfs

Distinctions between Typic Natraqualfs and other subgroups

Typic Natraqualfs are Natraqualfs that

a. Have >15 percent saturation with sodium or have more magnesium and sodium than calcium and extractable acidity within 15 cm of the upper boundary of the natric horizon;

b. Do not have tonguing or interfingering of albic materials more than 2.5 cm into the natric horizon;

c. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the soil to a depth of 18 cm, after mixing, has these colors; and

d. Have, within 40 cm of the soil surface, a horizon that has 15 percent or more saturation with sodium or has more magnesium and sodium than calcium and extractable acidity.

Albic Natraqualfs are like Typic Natraqualfs except for *a* or for *a* and *d*.

Albic Glossic Natraqualfs are like Typic Natraqualfs except for *b* and *d,* with or without *a*.

Glossic Natraqualfs are like Typic Natraqualfs except for *b*.

Mollic Natraqualfs are like Typic Natraqualfs except for *c,* with or without *d*.

Ochraqualfs

Distinctions between Typic Ochraqualfs and other subgroups

Typic Ochraqualfs are the Ochraqualfs that

a. Have in 60 percent or more of the matrix[5] in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and the mean annual soil temperature is lower than 15° C, chroma, moist, of 2 or less;

(2) If mottled and the mean annual soil temperature is 15° C or more:

(a) If the hue is 2.5Y or redder and the value, moist, is more than 5, the chroma is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(c) If the hue is yellower than 2.5Y, the chroma, moist is 2 or less;

(3) The chroma, moist, is 1 or less whether mottled or not;

b. Do not have a layer above a depth of 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either

(1) A ratio of measured clay to 15-bar water (percentages) or 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the upper soil to a depth of 18 cm, after mixing, has these color values;

d. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the surface; and

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and that extend upward to the surface or to the base of an Ap or an albic horizon,

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper soil to a depth of 1 m or in the whole soil if a lithic, paralithic, or petroferric contact is deeper than 50 cm but not deeper than 1 m, and

(3) More than 35 percent clay in horizons that have total thickness of >50 cm.

Aeric Ochraqualfs are like Typic Ochraqualfs except for *a*.

Aeric Umbric Ochraqualfs are like Typic Ochraqualfs except for *a* and *c* and have an epipedon that meets all the requirements of an umbric epipedon except thickness.

Andaqueptic Ochraqualfs are like Typic Ochraqualfs except for *b* or for *a* and *b*.

Arenic Ochraqualfs are like Typic Ochraqualfs except for *d,* with or without *a,* or *c,* or both, and have a sandy epipedon between 50 cm and 1 m thick.

Grossarenic Ochraqualfs are like Typic Ochraqualfs except for *d,* or for *a* and *d,* and have a sandy epipedon >1 m thick.

Mollic Ochraqualfs are like Typic Ochraqualfs except for *c* and have an epipedon that meets all the requirements of a mollic epipedon except thickness.

Udollic Ochraqualfs are like Typic Ochraqualfs except for *a* and *c* and have an epipedon that meets all the requirements of a mollic epipedon except thickness.

Umbric Ochraqualfs are like Typic Ochraqualfs except for *c* and have an epipedon that meets all the requirements of a umbric epipedon except thickness.

Vertic Ochraqualfs are like Typic Ochraqualfs except for *e* with or without *a* or *c*, or both.

Plinthaqualfs

Definition

Plinthaqualfs are the Aqualfs that have plinthite that forms a continuous phase or that constitutes half or more of the matrix of some subhorizon of the argillic horizon within 1.25 m of the soil surface.

Tropaqualfs

Distinctions between Typic Tropaqualfs and other subgroups

Typic Tropaqualfs are the Tropaqualfs that

a. Have in 60 percent or more of the matrix[6] in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and the mean annual soil temperature is lower than 15° C, moist chroma of 2 or less;

(2) If mottled and the mean annual soil temperature is 15° C or higher:

(a) If the hue is 2.5Y or redder and the value, moist, is more than 5, chroma, moist, of 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, chroma, moist, of 1 or less;

(c) If the hue is yellower than 2.5Y, chroma, moist, of 2 or less; or

(3) Chroma, moist, of 1 or less whether mottled or not;

b. Do not have an increase of as much as 20 percent clay (absolute) within a vertical distance of 7.5 cm or of as much as 15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon;

c. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Have either an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed, or the upper soil to a depth of 18 cm has these colors after mixing; and

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and extend upward to the surface or to the base of an Ap or of an albic horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09

or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the soil to a depth of 1 m or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Abruptic Tropaqualfs are like Typic Tropaqualfs except for *b*.

Aeric Tropaqualfs are like Typic Tropaqualfs except for *a*.

Umbraqualfs

Distinctions between Typic Umbraqualfs and other subgroups

Typic Umbraqualfs are the Umbraqualfs that

a. Do not have a layer above a depth of 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum; and

b. Do not have, in the umbric epipedon and in horizons above the argillic horizon, soft discrete nodules 2.5 to 30 cm in diameter that constitute >5 percent of the volume, that are cemented by iron, and that lie above and in an irregular or broken upper boundary of the argillic horizon.

The typic subgroup is the only one that has been recognized in the United States to date. Item *a* of the definition of Typic Umbraqualfs provides for an andeptic subgroup, and item *b* has been suggested for a ferrudalfic subgroup.

The Umbraqualfs are not extensive in the United States. Most of them formed in alluvium or in marine deposits and are nearly level. The base saturation in the argillic horizon generally is low enough that liming the surface layer does not change the classification.

BORALFS

Key to great groups

HBA. Boralfs that have an argillic horizon with its upper boundary deeper than 60 cm below the mineral surface,[7] that have texture finer than loamy fine sand in some subhorizon above the argillic horizon, and that have albic materials tonguing or interfingering in the argillic horizon.

Paleboralfs, p. 70

HBB. Other Boralfs that have a fragipan.

Fragiboralfs, p. 69

HBC. Other Boralfs that have a natric horizon.

Natriboralfs, p. 70

HBD. Other Boralfs that have a cryic temperature regime.

Cryoboralfs, p. 68

HBE. Other Boralfs that have base saturation (by sum of cations) of 60 percent or more in all subhorizons of the argillic horizon and are dry in some horizon at some time in most years.

Eutroboralfs, p. 69

HBF. Other Boralfs that either are never dry in any horizon in most years or have base saturation (by sum of cations) of <60 percent in some subhorizon of the argillic horizon.

Glossoboralfs, p. 69

Cryoboralfs

Distinctions between Typic Cryoboralfs and other subgroups

Typic Cryoboralfs are the Cryoboralfs that

a. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water >1.5 and has more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have albic materials tonguing in an argillic horizon;

c. Do not have a lithic contact within 50 cm of the surface;

d. Have an Ap horizon that has a color value, moist, of more than 3, or the upper soil, to a depth of 15 cm after mixing, has a moist color value of 4 or more;

e. Have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (not in lamellae); and

f. Do not have mottles that have chroma of 2 or less within 75 cm of the surface, or the soils are not continuously saturated with water for as long as 3 months within 1 m of the surface where undrained.

Andeptic Cryoboralfs are like Typic Cryoboralfs except for *a* or for *a* and *b*.

Aquic Cryoboralfs are like Typic Cryoboralfs except for *f*, with or without *b* or *d*, or both.

Glossic Cryoboralfs are like Typic Cryoboralfs except for *b*.

Lithic Cryoboralfs are like Typic Cryoboralfs except for *c*.

Lithic Mollic Cryoboralfs are like Typic Cryoboralfs except for *c* and *d*, with or without *b*.

Mollic Cryoboralfs are like Typic Cryoboralfs except for *d* or *b* and *d*.

Psammentic Cryoboralfs are like Typic Cryoboralfs except for *e*, with or without *b* or *d*, or both.

Eutroboralfs

Distinctions between Typic Eutroboralfs and other subgroups

Typic Eutroboralfs are the Eutroboralfs that

a. Do not have mottles that have chroma of 2 or less in the

upper 25 cm of the argillic horizon if the mottled horizons are saturated with water at a time when the soil temperature is 5° C or higher (this does not exclude the presence of bleached silt or sand coatings on peds beside or below tongues of albic materials);
b. Have a texture finer than loamy fine sand in some subhorizon within 50 cm of the surface;
c. Do not have tongues of albic materials in the argillic horizon (interfingering is permitted);
d. Do not have a lithic contact within 50 cm of the surface;
e. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed), or the soil to a depth of 18 cm, after mixing, has these colors; and
f. Have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (not in lamellae).

Aquic Eutroboralfs are like Typic Eutroboralfs except for *a,* with or without all or any of *b, c, e,* or *f.*

Arenic Eutroboralfs are like Typic Eutroboralfs except for *b,* with or without *c* or *e,* or both.

Glossic Eutroboralfs are like Typic Eutroboralfs except for *c.*

Lithic Eutroboralfs are like Typic Eutroboralfs except for *d,* with or without all or any of *a, b, e,* or *f.*

Mollic Eutroboralfs are like Typic Eutroboralfs except for *e.*

Psammentic Eutroboralfs are like Typic Eutroboralfs except for *f* with or without all or any of *b, c,* or *e.*

Fragiboralfs

Distinctions between Typic Fragiboralfs and other subgroups

Typic Fragiboralfs are the Fragiboralfs that
a. Do not have mottles that have chroma of 2 or less (defined in ch. 3) in the upper 25 cm of the argillic horizon (bleached coatings of silt or sand may be on peds beside or below tongues of the albic horizon).

Aquic Fragiboralfs are like Typic Fragiboralfs except they have mottles that have chroma of 2 or less within the upper 25 cm of the argillic horizon and are saturated with water at some time within this depth.

Glossoboralfs

Distinctions between Typic Glossoboralfs and other subgroups

Typic Glossoboralfs are the Glossoboralfs that
a. Do not have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon if the mottled horizons are saturated with water at a time when the soil temperature is 5° C or higher (bleached coatings of silt or sand may be on peds beside or below tongues of the albic horizon);
b. Have tongues of albic materials in the argillic horizon;

c. Do not have a lithic contact within 50 cm of the soil surface; and
d. Have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (not in lamellae).

Aquic Glossoboralfs are like Typic Glossoboralfs except for *a,* with or without *b* or *d,* or both.

Eutric Glossoboralfs are like Typic Glossoboralfs except for *b.*

Lithic Glossoboralfs are like Typic Glossoboralfs except for *c,* with or without *a* or *b,* or both.

Psammentic Glossoboralfs are like Typic Glossoboralfs except for *d,* with or without *b.*

Natriboralfs

Natriboralfs are the Boralfs that have a natric horizon. They are rare in the United States, and subgroups have not been developed.

Paleboralfs

Distinctions between Typic Paleboralfs and other subgroups

Typic Paleboralfs are the Paleboralfs that
a. Have an argillic horizon that has an increase in clay content of <20 percent (absolute) within a vertical distance of 7.5 cm from its upper boundary;
b. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
c. Do not have mottles that have chroma of 2 or less within 1 m of the surface; and
d. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed, or the soil to a depth of 18 cm has these colors after mixing.

Aquic Paleboralfs are like Typic Paleboralfs except for *c.*

Mollic Paleboralfs are like Typic Paleboralfs except for *d.*

The Paleboralfs have had relatively little study in the field or laboratory. It seems best at this time to consider the definitions of the great group and of its subgroups as tentative.

UDALFS

Key to great groups

HEA. Udalfs that have an agric horizon.

Agrudalfs, p. 71

HEB. Other Udalfs that have a natric horizon.

Natrudalfs, p. 75

HEC. Other Udalfs that

1. Do not have a continuous albic horizon above the argillic horizon;
2. Have a broken upper boundary of the argillic horizon; and
3. Have discrete nodules in the argillic horizon that range from 2.5 to 5 cm to about 30 cm in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hue or stronger chroma than interiors of nodules.

Ferrudalfs, p. 72

HED. Other Udalfs that have tongues of albic materials in the argillic horizon and do not have a fragipan.

Glossudalfs, p. 73

HEE. Other Udalfs that have tongues of albic materials in the argillic horizon and have a fragipan.

Fraglossudalfs, p. 73

HEF. Other Udalfs that have a fragipan.

Fragiudalfs, p. 72

HEG. Other Udalfs that

1. Have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more;
2. Do not have a lithic or paralithic contact within 1.5 m of the soil surface;
3. Have clay distribution such that the percentage of clay does not decrease by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface or the horizon in which the clay decreases either has >5 percent plinthite by volume or has skeletans or other evidence of clay eluviation; and
4. Have one or more of the following in the argillic horizon:
   a. Hue redder than 10YR and chroma more than 4 dominant in the matrix in at least the lower part;
   b. Hue of 2.5YR or redder and value, moist, of less than 4 and value, dry, of less than 5 throughout the major part;
   c. Many coarse mottles that have hue redder than 7.5YR or chroma more than 5, or both in some subhorizon.

Paleudalfs, p. 76

HEH. Other Udalfs that have an argillic horizon that has throughout its thickness a hue redder than 5YR, a color value, moist of less than 4, and a color value, dry, no more than 1 unit higher than the value, moist.

Rhodudalfs, p. 77

HEI. Other Udalfs that have mean summer and mean winter soil temperatures that differ by <5° C at a depth of 50 cm or at a lithic or a paralithic contact, whichever is shallower.

Tropudalfs, p. 77

HEJ. Other Udalfs.

Hapludalfs, p. 74

Agrudalfs

Agrudalfs are the Udalfs that have an agric horizon. Some but not all have an anthropic epipedon. They have been in farms for many hundreds of years and have received heavy applications of animal manure and other amendments. They are not known to occur in the United States. It seems probable that only the typic and anthropic subgroups are needed. The Agrudalfs of western Europe

have been farmed for more than 1,000 years,[8] and the early farmers selected only the best soils for cultivation. All of them are well drained, and they seem quite similar in most properties. The Typic Agrudalfs do not have an anthropic epipedon.

Ferrudalfs

Distinctions between Typic Ferrudalfs and other subgroups

Typic Ferrudalfs are the Ferrudalfs that

a. Do not have mottles that have chroma of 2 or less within the upper 60 cm if the horizons that have mottles of low chroma are saturated with water at some time of year or if the soil has artificial drainage. The mottles should be distinguished from skeletans that may also have low chroma.

Aquic Ferrudalfs are like Typic Ferrudalfs except for *a.*

Fragiudalfs

Distinctions between Typic Fragiudalfs and other subgroups

Typic Fragiudalfs are the Fragiudalfs that

a. Have an argillic horizon above the fragipan that has clay skins on at least some vertical and horizontal faces of primary or secondary peds, or both;

b. Do not have, immediately above the fragipan, thick skeletans of clean sand and silt on primary ped faces and do not have an eluvial horizon (A'2) that has thick skeletans and as much as 3 percent (absolute) less clay than both the overlying and underlying horizons;

c. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Either have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more, when crushed and smoothed, or the soil to a depth of 18 cm, after mixing, has those colors; and

e. Do not have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon and do not have mottles that have chroma of 2 or less within 40 cm of the surface if the horizons that have mottles of low chroma are saturated with water at some time of year when the soil temperature is 5° C or higher in those horizons. Mottles are not the same as skeletans that may also have low chroma.

Albaquic Fragiudalfs are like Typic Fragiudalfs except for *e,* and they have, within a vertical distance of 7.5 cm at the top of the argillic horizon, a clay increase of >15 percent (absolute) in the fine-earth fraction.

Aqueptic Fragiudalfs are like Typic Fragiudalfs except for *a* and *e*.

Aquic Fragiudalfs are like Typic Fragiudalfs except for *e*.

Glossaquic Fragiudalfs are like Typic Fragiudalfs except for *b* and *e*, with or without *a*.

Glossic Fragiudalfs are like Typic Fragiudalfs except for *b*, with or without *a*.

Mollic Fragiudalfs are like Typic Fragiudalfs except for *d*, with or without *e*, and have base saturation of 50 percent or more (by NH_4OAc) in the major part of the epipedon.

Ochreptic Fragiudalfs are like Typic Fragiudalfs except for *a*.

Umbreptic Fragiudalfs are like Typic Fragiudalfs except for *a*, *b*, and *d*, and have base saturation <50 percent (by NH_4OAc) in the epipedon.

ALF

Fraglossudalfs

Fraglossudalfs have a fragipan and an overlying argillic horizon that has evidences of destruction in the form of deep wide tongues of albic materials that normally extend through the argillic horizon. The upper boundary of the argillic horizon is usually broken, but there is little or no cementation by iron. These soils are more extensive in Europe than in the United States. The epipedon may approach an umbric epipedon. Subgroups have not been developed. No comparable class existed in the 1938 classification.

Glossudalfs

Distinctions between Typic Glossudalfs and other subgroups

Typic Glossudalfs are the Glossudalfs that

a. Do not have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon if the mottled horizons are saturated with water at some season when their temperature is 5°C or higher;

b. Have tongues of albic materials that extend through at least the upper 50 cm of the argillic horizon;

c. Do not have a brittle matrix in one-fourth or more of some subhorizon that is at least 10 cm thick and that has an upper boundary within 1.25 m of the surface; and

d. Have within 50 cm of the surface a texture finer than loamy fine sand in some subhorizon.

Aquic Glossudalfs are like Typic Glossudalfs except for *a*, with or without *b*.

Arenic Glossudalfs are like Typic Glossudalfs except for *d*.

Fragic Glossudalfs are like Typic Glossudalfs except for *c*, or for *a* and *c*.

Haplic Glossudalfs are like Typic Glossudalfs except for *b*.

Hapludalfs

Distinctions between Typic Hapludalfs and other subgroups

Typic Hapludalfs are the Hapludalfs that

a. Do not have an abrupt textural change if there are mottles in the upper 25 cm of the argillic horizon;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an argillic horizon that

(1) If its upper boundary is <50 cm below the soil surface, does not have mottles that have chroma of 2 or less in the upper 25 cm if it is saturated with water within that depth at some time when the soil temperature is 5° C or higher; or

(2) If the upper boundary of the argillic horizon is deeper than 50 cm, does not have mottles that have chroma of 2 or less within a depth of 75 cm below the soil surface;

d. Have, within 50 cm of the surface, texture finer than loamy fine sand in some subhorizon;

e. Do not have interfingering of albic materials and albic materials surrounding some peds in the upper part of the argillic horizon;

f. Do not have a lithic contact within 50 cm of the soil surface;

g. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more (crushed and smoothed) or the upper soil to a depth of 18 cm, after mixing, has these colors;

h. Have an argillic horizon that is continuous horizontally and continuous vertically for at least the upper 20 cm of its thickness and that has texture finer than loamy fine sand;

i. Have base saturation (by sum of cations) of 60 percent or more at a depth 1.25 m below the top of the argillic horizon, or 1.8 m below the soil surface, or immediately above a lithic or paralithic contact, whichever is least;

j. Do not have the following combinations of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and that extend to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic

or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness within the control section; and

k. Do not have albic materials that constitute as much as 5 percent of the volume of any subhorizon of the argillic horizon.

Albaquic Hapludalfs are like Typic Hapludalfs except for *a* and *c*, with or without *g*.

Albaquultic Hapludalfs are like Typic Hapludalfs except for *a*, *c*, and *i*.

Andeptic Glossoboric Hapludalfs are like Typic Hapludalfs except for *b* and *e*, and their mean annual soil temperature is lower than 10°C.

Aquic Hapludalfs are like Typic Hapludalfs except for *c*.

Aquic Arenic Hapludalfs are like Typic Hapludalfs except for *c* and *d*, with or without *g* or *i*, or both.

Aquic Lithic Hapludalfs are like Typic Hapludalfs except for *c* and *f*.

Aquollic Hapludalfs are like Typic Hapludalfs except for *c* and *g*.

Aquultic Hapludalfs are like Typic Hapludalfs except for *c* and *i*, with or without *g*.

Arenic Hapludalfs are like Typic Hapludalfs except for *d*, with or without *g* or *i*, or both.

Glossaquic Hapludalfs are like Typic Hapludalfs except for *e* and *c* or for *e*, *c*, and *g*.

Glossic Hapludalfs are like Typic Hapludalfs except for *k*, with or without *e* or *g*, or both, and the mean annual soil temperature is 10°C or higher.

Glossoboric Hapludalfs are like Typic Hapludalfs except for *e* or for *e* and *g*, and their mean annual soil temperature is lower than 10°C.

Lithic Hapludalfs are like Typic Hapludalfs except for *f*, with or without *g*.

Mollic Hapludalfs are like Typic Hapludalfs except for *g*.

Psammaquentic Hapludalfs are like Typic Hapludalfs except for *c* and *h*, with or without all or any of *d*, *g*, or *i*.

Psammentic Hapludalfs are like Typic Hapludalfs except for *h*, with or without all or any of *d*, *g*, or *i*.

Ultic Hapludalfs are like Typic Hapludalfs except for *i*, with or without *g*.

Vertic Hapludalfs are like Typic Hapludalfs except for *j*, with or without any or all of *a*, *c*, *g*, and *i*.

ALF

Natrudalfs

Distinctions between Typic Natrudalfs and other subgroups

Typic Natrudalfs are the Natrudalfs that

a. Have mottles that have chroma of 2 or less within 25 cm of the upper boundary of the natric horizon;

b. Have an Ap horizon that has a color value, moist, of 3 or more, or the soil to a depth of 18 cm, after mixing, has that color value;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part and that extend to the surface or to the base of an Ap horizon;
(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

d. Do not have tonguing or interfingering of albic materials more than 2.5 cm into the natric horizon.

Glossic Natrudalfs are like Typic Natrudalfs except for *d.*

Vertic Natrudalfs are like Typic Natrudalfs except for *c.*

Paleudalfs

Distinctions between Typic Paleudalfs and other subgroups

Typic Paleudalfs are the Paleudalfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizons are saturated with water at some time when the soil temperature at that depth is 5°C or higher or the soil has artificial drainage;

b. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the surface;

c. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed), or the upper soil to a depth of 18 cm, after mixing, has these colors;

d. Have an argillic horizon that has a color value, dry, of 5 or more in some subhorizon, or a color value, moist, that is less than the value, dry, by more than one unit unless the hue in some part of the argillic horizon is 5YR or yellower;

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part and that extend upward to the surface or to the base of an Ap horizon unless the hue in some part of the argillic horizon is 5YR or yellower;
(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness;

f. Have ≥5 percent plinthite (by volume) in all subhorizons within 1.5 m of the surface;

g. Have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm, and that has a texture finer than loamy fine sand;
h. Do not have subhorizons in the upper part of the argillic horizon that have skeletans that
(1) Have moist chroma of 2 or less; and
(2) Occupy 5 percent or more of the volume of the subhorizon;
i. Do not have albic materials that constitute as much as 5 percent of any subhorizon of the argillic horizon.

Albaquic Paleudalfs are like Typic Paleudalfs except for *a* and have an increase of 15 percent clay or more (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon.

Aquic Paleudalfs are like Typic Paleudalfs except for *a*, with or without *c*.

Arenic Paleudalfs are like Typic Paleudalfs except for *b* and have a sandy epipedon that is between 50 cm and 1 m thick.

Arenic Plinthic Paleudalfs are like Typic Paleudalfs except for *b* and *f* and have a sandy epipedon that is between 50 cm and 1 m thick.

Glossaquic Paleudalfs are like the Typic Paleudalfs except for *a* and *h*, with or without *c* or *i*, or both.

Glossic Paleudalfs are like Typic Paleudalfs except for *h* or *i*, or both.

Grossarenic Paleudalfs are like Typic Paleudalfs except for *b* and have a sandy epipedon that is >1 m thick.

Grossarenic Plinthic Paleudalfs are like Typic Paleudalfs except for *b* and *f* and have a sandy epipedon that is >1 m thick.

Mollic Paleudalfs are like Typic Paleudalfs except for *c*.

Plinthaquic Paleudalfs are like Typic Paleudalfs except for *a* and *f* with or without *c*.

Plinthic Paleudalfs are like Typic Paleudalfs except for *f* with or without *c*.

Psammentic Paleudalfs are like Typic Paleudalfs except for *g*, with or without *b* or *c*, or both.

Rhodic Paleudalfs are like Typic Paleudalfs except for *c* and *d*.

Vertic Paleudalfs are like Typic Paleudalfs except for *e*, with or without *a* or *c*, or both.

Rhodudalfs

Rhodudalfs are dark red Udalfs of midlatitudes that have a thinner solum than the Paleudalfs. The definition is parallel to that of other Rhodic great groups. Their parent materials are basic. These soils are rare in the United States. Definitions of subgroups have not been developed.

Tropudalfs

Distinctions between Typic Tropudalfs and other subgroups

Typic Tropudalfs are the Tropudalfs that
a. Do not have mottles that have chroma of 2 or less within

75 cm of the soil surface if the mottled horizons are saturated with water at some time during the year or the soil has artificial drainage;
b. Do not have a lithic contact within 50 cm of the soil surface;
c. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3- bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or
(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Do not have an abrupt textural change if there are mottles in the upper 25 cm of the argillic horizon;
e. Have texture finer than loamy fine sand in some subhorizon within a depth of 50 cm from the soil surface;
f. Have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm, and that has a texture finer than loamy fine sand;
g. Have base saturation (by sum of cations) of 60 percent or more at a depth 1.25 m below the top of the argillic horizon;
h. Have CEC that is 24 or more meq per 100 g clay (by NH_4OAc) and that have a cation retention from NH_4Cl that is 12 or more meq per 100 g clay in the major part of the argillic horizon; and
i. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, that extend to the surface or to the base of an Ap horizon;
(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Tropudalfs are like Typic Tropudalfs except for a.
Lithic Tropudalfs are like Typic Tropudalfs except for *b.*
Oxic Tropudalfs are like Typic Tropudalfs except for *h,* with or without *g.*
Ultic Tropudalfs are like Typic Tropudalfs except for *g.*
Vertic Tropudalfs are like Typic Tropudalfs except for *i,* with or without *a* or *d,* or both.

USTALFS

Key to great groups

HCA. Ustalfs that have a duripan that has its upper boundary within 1 m of the surface.

Durustalfs, p. 79

HCB. Other Ustalfs that have plinthite that forms a continuous phase or constitutes more than half the matrix within some subhorizon of the argillic horizon within 1.25 m of the surface.

Plinthustalfs, p. 83

HCC. Other Ustalfs that have a natric horizon.

Natrustalfs, p. 81

HCD. Other Ustalfs that either have a petrocalcic horizon that has its upper boundary within 1.5 m of the surface or;

1. Does not have a lithic or paralithic contact within 1.5 m of the surface; and the argillic horizon

a. Has a clay distribution such that the percentage of clay does not decrease by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface, or the horizon in which the clay decreases either has >5 percent plinthite by volume or has skeletans or evidences of clay eluviation; and

b. Has one or more of the following:

(1) Hues redder than 10YR and chroma of more than 4 in the matrix of at least the lower part of the horizon;

(2) Hues of 7.5YR or redder and value, moist, that is less than 4 and value, dry, that is less than 5 throughout the major part of the horizon; or

(3) Common coarse mottles that have hue of 7.5YR or redder or chroma of more than 5 in the lower part of the horizon; or

2. Does not have a lithic or paralithic contact within 50 cm of the surface and has an argillic horizon in which the upper part has a clayey particle-size class and there is an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm, or of at least 15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary.

Paleustalfs, p. 81

HCE. Other Ustalfs that have an argillic horizon that has throughout its thickness a hue redder than 5YR, a color value, moist, less than 4, and a color value, dry, no moie than one unit higher than the value moist.

Rhodustalfs, p. 83

HCF. Other Ustalfs.

Haplustalfs, p. 79

Durustalfs

Durustalfs are the Ustalfs that have a duripan whose upper boundary is within 1 m of the surface. They are not known to occur in the United States, and subgroups have not been developed. They are provided for use in other countries.

Haplustalfs

Distinctions between Typic Haplustalfs and other subgroups

Typic Haplustalfs are the Haplustalfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time during the year or the soil has artificial drainage;

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b. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the soil surface;
c. Do not have a lithic contact within 50 cm of the soil surface;
d. Have CEC of 24 or more meq per 100 g clay (by NH_4OAc) and have cation retention from NH_4 Cl of 12 or more meq per 100 g clay in the major part of the argillic horizon (see discussion of the oxic horizon, ch.3, for a definition of cation retention);
e. Have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm, that is not composed entirely of lamellae, and that has a texture finer than loamy fine sand;
f. Have a calcic horizon or soft, powdery secondary lime within 1.25 m of the soil surface if the weighted average particle-size class of the upper 50 cm of the argillic horizon[9] is sandy, within 90 cm if it is loamy, and within 70 cm if it is clayey;
g. Have an argillic horizon that has base saturation (by sum of cations) of 75 percent or more in some part;
h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend to the surface or to the base of an Ap horizon if the soil is not irrigated;
(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and
(3) More than 35 percent clay in horizons that total $>$50 cm in thickness; and

i. When neither irrigated nor fallowed to store moisture:

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C; or
(2) If the soil temperature regime is hyperthermic, or isomesic or a warmer iso-temperature regime, the soils are moist in most years in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C.

Aquic Haplustalfs are like Typic Haplustalfs except for *a* or for *a* and *f*.

Aquic Arenic Haplustalfs are like Typic Haplustalfs except for *a* and *b*, with or without *f* or *g*, or both.

Aquultic Haplustalfs are like Typic Haplustalfs except for *a* and *g*, with or without *f*.

Arenic Haplustalfs are like Typic Haplustalfs except for *b*, with or without *f* or *g*, or both.

Arenic Aridic Haplustalfs are like Typic Haplustalfs except for *b* and *i*, with or without *f*.

Aridic Haplustalfs are like Typic Haplustalfs except for *i* or for *f* and *i*.

Lithic Haplustalfs are like Typic Haplustalfs except for *c*, with or without *f* or *i*, or both.

Oxic Haplustalfs are like Typic Haplustalfs except for *d*, with or without *g* or *f*, or both.

Psammentic Haplustalfs are like Typic Haplustalfs except for *e*, with or without any or all of *b*, *f*, and *g*.

Udic Haplustalfs are like Typic Haplustalfs except for *f*.

Ultic Haplustalfs are like Typic Haplustalfs except for *g* or for *f* and *g*.

Vertic Haplustalfs are like Typic Haplustalfs except for *h*, with or without any or all of *a*, *f*, and *i*.

Natrustalfs

Distinctions between Typic Natrustalfs and other subgroups

Typic Natrustalfs are the Natrustalfs that

a. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface if there is ground water in the mottled horizon at some time of year when the soil temperature is 5° C or higher;

b. Have an Ap horizon that has a color value, moist, more than 3, or the surface soil to a depth of 18 cm, after mixing, has a color value, moist, more than 3;

c. Do not have a salic horizon that has its upper boundary within 75 cm of the soil surface; and

d. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the surface.

Aquic Natrustalfs are like Typic Natrustalfs except for *a*, with or without *b*.

Mollic Natrustalfs are like Typic Natrustalfs except for *b*.

Petrocalcic Natrustalfs are like Typic Natrustalfs except for *d*.

Salorthidic Natrustalfs are like Typic Natrustalfs except for *c*.

Paleustalfs

Distinctions between Typic Paleustalfs and other subgroups

Typic Paleustalfs are the Paleustalfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when the temperature of the horizon is 5° C or higher;

b. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the soil surface;

c. Have <5 percent plinthite by volume in all subhorizons within 1.5 m of the soil surface;

d. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy,

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within a depth of 90 cm if the argillic horizon is loamy, and within a depth of 70 cm if it is clayey;
e. Have an argillic horizon that has base saturation (by sum of cations) of 75 percent or more in some part;
f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon if the soil is not irrigated;
(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and
(3) More than 35 percent clay in horizons that total $>$50 cm in thickness;

g. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface;
h. When not irrigated and when not fallowed to store moisture:

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C; or
(2) If the soil temperature regime is hyperthermic, isomesic, or warmer, are moist in most years in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C;

i. Have CEC of 24 or more meq per 100 g clay (by NH_4OAc) and have cation retention from NH_4Cl of 12 or more meq per 100 g clay in the major part of the argillic horizon;
j. Have an argillic horizon that has a color hue of 5YR or yellower in some part, or has a value, moist, of 4 or more in some part, or has a value, dry, that is more than one unit higher than the value, moist; and
k. Have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm, and that has a texture finer than loamy fine sand.

Aquic Paleustalfs are like Typic Paleustalfs except for *a,* with or without *d* or *e,* or both.

Aquic Arenic Paleustalfs are like Typic Paleustalfs except for *a* and *b,* with or without *d* or *e,* or both, and they have a sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Arenic Paleustalfs are like Typic Paleustalfs except for *b* or for *b* and *d,* and they have a sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Arenic Aridic Paleustalfs are like Typic Paleustalfs except for *b* and *h,* with or without *d,* and they have a

sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Aridic Paleustalfs are like Typic Paleustalfs except for *h*, and either they are noncalcareous in some subhorizon above the calcic horizon or they do not have a calcic horizon whose upper boundary is within a depth of 1 m below the soil surface if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, or 60 cm if it is loamy, or 50 cm if it is clayey.

Calciorthidic Paleustalfs are like Typic Paleustalfs except for *h*, and they have a calcic horizon within a depth of 1 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, 60 cm if it is loamy, or 50 cm if it is clayey, and they have carbonates in all subhorizons above the calcic horizon.

Grossarenic Paleustalfs are like Typic Paleustalfs except for *b*, with or without *a* or *d*, or both, and they have a sandy epipedon (loamy fine sand or coarser) >1 m thick.

Oxic Paleustalfs are like Typic Paleustalfs except for *i*, with or without *d* or *e*, or both, they have CEC <24 meq per 100 g clay, and they do not have an abrupt upper boundary of the argillic horizon.

Petrocalcic Paleustalfs are like Typic Paleustalfs except for *g*, with or without *h* or *j*, or both.

Psammentic Paleustalfs are like Typic Paleustalfs except for *k*, with or without some or all of *b*, *d*, or *e*.

Rhodic Paleustalfs are like Typic Paleustalfs except for *j*, with or without *d* or *e* or both, and the hue in the argillic horizon is redder than 5YR in all parts.

Udertic Paleustalfs are like Typic Paleustalfs except for *d* and *f*, with or without *a* or *h*, or both.

Udic Paleustalfs are like Typic Paleustalfs except for *d*.

Ultic Paleustalfs are like Typic Paleustalfs except for *e* and *d*, and they have either CEC <24 meq per 100 g clay or an abrupt upper boundary of the argillic horizon.

Plinthustalfs

Plinthustalfs are the Ustalfs that have plinthite that forms a continuous phase or that constitutes more than half the matrix of some subhorizon of the argillic horizon within 1.25 m of the soil surface. There are no soil series in the United States that are presently classified in this great group, but the group is provided for other parts of the world. Subgroups have not been developed. Plinthustalfs were included with Ground-Water Laterite soils in the 1938 classification.

Rhodustalfs

Distinctions between Typic Rhodustalfs and other subgroups

Because these soils are rare in the United States, the classification that follows probably is incomplete, and it is provisional.

Typic Rhodustalfs are the Rhodustalfs that

a. Do not have a lithic contact within 50 cm of the soil surface;

b. Have CEC of 24 or more meq per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is 12 or more meq per 100 g clay in the major part of the argillic horizon; and

c. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m from the surface if the weighted average particle-size class is sandy, 90 cm if it is loamy, and 70 cm if it is clayey.

Lithic Rhodustalfs are like Typic Rhodustalfs except for *a,* with or without *c.*

Oxic Rhodustalfs are like Typic Rhodustalfs except for *b,* with or without *c.*

Udic Rhodustalfs are like Typic Rhodustalfs except for *c.*

XERALFS

Key to great groups

HDA. Xeralfs that have a duripan whose upper boundary is within 1 m of the soil surface but below an argillic or a natric horizon.

Durixeralfs, p. 85

HDB. Other Xeralfs that have a natric horizon.

Natrixeralfs, p. 87

HDC. Other Xeralfs that have a fragipan.

Fragixeralfs, p. 85

HDD. Other Xeralfs that have plinthite that forms a continuous phase in or constitutes more than half the matrix of some subhorizon of the argillic horizon within 1.25 m of the soil surface.

Plinthoxeralfs, p. 88

HDE. Other Xeralfs that have an argillic horizon that, in all parts, has a color hue redder than 5YR and a value, moist, less than 4 and a value, dry, no more than one unit higher than the value, moist.

Rhodoxeralfs, p. 88

HDF. Other Xeralfs that have either a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface or have one or both of

1. A vertical clay distribution such that the percentage of clay does not decrease from the maximum by as much as 20 percent of that maximum throughout a depth of 1.5 m from the soil surface, or the horizon in which the clay decreases has either

a. More than 5 percent by volume of plinthite; or

b. Skeletans or other evidences of clay eluviation, and there is no lithic or paralithic contact within 1.5 m of the soil surface, and either

(1) A hue redder than 10YR and chroma more than 4 in the matrix of at least the lower part of the argillic horizon; or

(2) Common coarse mottles that have a hue of 7.5YR or redder or chroma greater than 5 or both in the lower part of the argillic horizon;

2. An argillic horizon that has a clayey particle-size class in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or at least 15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary; and there is no lithic or paralithic contact within 50 cm of the surface of the soil.

Palexeralfs, p. 87

HDG. Other Xeralfs.

Haploxeralfs, p. 86

Durixeralfs

Distinctions between Typic Durixeralfs and other subgroups

Typic Durixeralfs are the Durixeralfs that

a. Have an argillic horizon that has <35 percent clay in all parts, or the increase in clay content is <15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon, or the increase is <10 percent clay (absolute) if the soil is cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;

b. Do not have mottles in the argillic horizon that have chroma of 2 or less;

c. Have a duripan that is massive, platy, or prismatic and that has half or more of its upper boundary indurated and coated with opal or with opal and sesquioxides or that is indurated in some subhorizon below the upper boundary; and

d. Do not have a natric horizon.

Abruptic Durixeralfs are like Typic Durixeralfs except for *a*.

Abruptic Haplic Durixeralfs are like Typic Durixeralfs except for *a* and *c*.

Haplic Durixeralfs are like Typic Durixeralfs except for *c*.

Natric Durixeralfs are like Typic Durixeralfs except for *d*, with or without *b* or *c*, or both.

Fragixeralfs

Distinctions between Typic Fragixeralfs and other subgroups

Typic Fragixeralfs are the Fragixeralfs that

a. Above the fragipan have an argillic horizon that has clay skins on at least some vertical and horizontal faces of primary or secondary peds, or both;

b. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of 1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Either have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more, when crushed and smoothed, or the soil to a depth of 18 cm, after mixing, has those colors; and

d. Do not have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon and do not have mottles that have chroma of 2 or less within 40 cm of the surface if the horizons that have mottles of low chroma are saturated with water at some time of the year when the soil temperature is 5° C or higher in those horizons. Mottles are not the same as skeletans, which also may have low chroma.

Mollic Fragixeralfs are like Typic Fragixeralfs except for *c,* with or without *d.*

Ochreptic Fragixeralfs are like Typic Fragixeralfs except for *a.*

Haploxeralfs

Distinctions between Typic Haploxeralfs and other subgroups

Typic Haploxeralfs are the Haploxeralfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time when the temperature of that horizon is 5°C or higher or there is artificial drainage;

b. Have an A1 horizon that throughout its upper 10 cm has a color value, moist, of 3.5 or more or has <0.7 percent organic carbon in some part, or have an Ap horizon that has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have exchangeable sodium that is <15 percent of the CEC (at pH 8.2) throughout the argillic horizon;

e. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m of the soil surface;

f. Have an argillic horizon that has base saturation (by sum of cations) of 75 percent or more throughout the upper 75 cm or to a lithic or paralithic contact, whichever is shallower;

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon if the soil is not irrigated;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

h. Have an argillic horizon that is continuous vertically for at least the upper 20 cm that is not composed entirely of lamellae, and that has a texture finer than loamy fine sand;

i. Do not have a calcic horizon that has its upper boundary within the upper 1 m of soil; and

j. Have an argillic horizon that is continuous horizontally throughout the area of each pedon.

Aquic Haploxeralfs are like Typic Haploxeralfs except for *a* or for *a* and *b.*

Aquultic Haploxeralfs are like Typic Haploxeralfs except for *a* and *f* with or without *b.*

Calcic Haploxeralfs are like Typic Haploxeralfs except for *i.*

Lithic Haploxeralfs are like Typic Haploxeralfs except for *c.*

Lithic Mollic Haploxeralfs are like Typic Haploxeralfs except for *c* and *b.*

Lithic Ruptic-Xerochreptic Haploxeralfs are like Typic Haploxeralfs except for *c* and *j.*

Mollic Haploxeralfs are like Typic Haploxeralfs except for *b.*

Natric Haploxeralfs are like Typic Haploxeralfs except for *d.*

Psammentic Haploxeralfs are like Typic Haploxeralfs except for *h,* with or without *b* or *f,* or both.

Ultic Haploxeralfs are like Typic Haploxeralfs except for *f* or for *f* and *b.*

Vertic Haploxeralfs are like Typic Haploxeralfs except for *g* or for *b* and *g.*

Natrixeralfs

Distinctions between Typic Natrixeralfs and other subgroups

Typic Natrixeralfs are the Natrixeralfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if there is ground water in the mottled horizon at some time when the temperature of that horizon is 5°C or higher.

Aquic Natrixeralfs are like Typic Natrixeralfs except for *a.*

Palexeralfs

Distinctions between Typic Palexeralfs and other subgroups

The list of subgroups is incomplete for the world. A few subgroups are defined that are not known to occur in the United States, but a number of others that have not yet been defined are known to exist.

Typic Palexeralfs are the Palexeralfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is 5° or higher or there is artificial drainage;

b. Do not have a calcic horizon within 1.5 m of the soil surface;

c. Have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon, or they have an Ap horizon that has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon;

d. Do not have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface;

e. Have an argillic horizon that has at least 75 percent base saturation (by sum of cations) in some part;

f. Have an argillic horizon in which the upper part has a clayey particle-size class and there is an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of at least 15 percent clay (absolute) within 2.5 cm at the upper boundary;
g. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m of the soil surface;
h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon if the soil is not irrigated; and
(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m, and
(3) More than 35 percent clay in horizons that total >50 cm in thickness;

i. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the soil surface; and
j. Have <15 percent saturation with sodium in all subhorizons within 1 m of the soil surface.

Aquic Palexeralfs are like Typic Palexeralfs except for *a* or for *a* and *c*.

Calcic Palexeralfs are like Typic Palexeralfs except for *b*.

Mollic Palexeralfs are like Typic Palexeralfs except for *c*.

Natric Palexeralfs are like Typic Palexeralfs except for *j*.

Petrocalcic Palexeralfs are like Typic Palexeralfs except for *d*, or for *d* and *f*.

Ultic Palexeralfs are like Typic Palexeralfs except for *e*, with or without *f* or *c*, or both.

Vertic Palexeralfs are like Typic Palexeralfs except for *h*, with or without *a* or *c*, or both.

Plinthoxeralfs

Plinthoxeralfs are the Xeralfs that have plinthite that forms a continuous phase or that constitutes more than half the matrix of some subhorizon within 1.25 m of the soil surface. Few of these soils are in the United States, but the soils are moderately extensive in some parts of the world. Subgroups have not been developed. The Plinthoxeralfs were included with Ground-Water Laterite soils in the 1938 classification.

Rhodoxeralfs

Distinctions between Typic Rhodoxeralfs and other subgroups

The list of subgroups that follows is incomplete because the soils are of such limited extent in the United States.

Typic Rhodoxeralfs are the Rhodoxeralfs that

a. Have an argillic horizon that is >15 cm thick and is continuous in each pedon;

b. Do not have a lithic contact within 50 cm of the soil surface;

c. Do not have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface; and

d. Do not have a calcic horizon whose upper boundary is within 1.5 m of the soil surface.

Calcic Rhodoxeralfs are like Typic Rhodoxeralfs except for *d.*

Lithic Rhodoxeralfs are like Typic Rhodoxeralfs except for *b.*

Petrocalcic Rhodoxeralfs are like Typic Rhodoxeralfs except for *c.*

[1] If the hue is redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived. Where the soil temperature regime is hyperthermic, isothermic, or isohyperthermic, chroma up to 4 is tentatively permitted if the hue is 2.5Y or 5Y and if mottles are distinct or prominent. Such soils are too few in the United States to permit testing these limits.

[2] If the lime is disseminated, the horizon(s) in which lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-size lime.

[3] Hydraulic conductivity is defined as the rate of internal watermovement under a unit potential gradient. In this text the term refers to vertical saturated hydraulic conductivity. Slow and very slow rates refer to 4 to 10 and less than 4 cm water per day respectively.

[4] If the hue of the matrix is 7.5YR or redder and, if peds are present, ped exteriors in the argillic horizon should have dominant chroma, moist, of 1 or less and ped interiors should have mottles that have chroma, moist, of 2 or less; if peds are absent, the chroma, moist, should be 1 or less immediately below any surface horizon that has color value, moist, less than 3.5.

[5] See footnote 4 above.

[6] See footnote 4 above.

[7] If there is a surface mantle that has >60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the surface of the mineral soil.

[8] Personal communication from R. Tavernier.

[9] The upper 50 cm of the argillic horizon or the whole argillic horizon if it is thinner than 50 cm is designated (ch. 3) as the control section for the particle-size classes of families of Alfisols. This is the meaning intended here.

Chapter 6
Aridisols

Key to suborders

EA. Aridisols that have an argillic or a natric horizon.

Argids, p. 91

EB. Other Aridisols.

Orthids, p. 99

ARGIDS

Key to great groups

EAA. Argids that have a duripan[1] below an argillic horizon and do not have a natric horizon.

Durargids, p. 91

EAB. Other Argids that have a duripan below a natric horizon.

Nadurargids, p. 95

EAC. Other Argids that have a natric horizon and do not have a petrocalcic horizon.

Natrargids, p. 96

EAD. Other Argids that do not have a lithic or paralithic contact within 50 cm of the soil surface, that have a petrocalcic horizon or that have an argillic horizon that has 35 percent or more clay in some part, and that have either:

1. An increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon; or

2. An increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.

Paleargids, p. 97

EAE. Other Argids.

Haplargids, p. 92

Durargids

Distinctions between Typic Durargids and other subgroups

Typic Durargids are the Durargids that

a. Are not saturated with water for 90 consecutive days or more within 1 m of the surface in most years and do not have any of the following characteristics within 1 m of the soil surface if there is ground water within this depth at some time in most years:

(1) Dominant chroma of 1 or less throughout the horizons and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime;

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable sodium) in more than half the thickness of the horizon between the surface and 50 cm depth than in the saturated zone;

b. Have a platy or massive duripan that is indurated in some subhorizon;

c. Have a duripan at a depth <18 cm; or the weighted

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average percentage of organic carbon in the upper soil to a depth of 40 cm is <0.6 if the weighted average ratio of sand to clay in the upper soil to that depth is 1.0 or less, or is less than one-seventh percent if the ratio is 13 or more, or is intermediate between 0.6 percent and one-seventh percent if the ratio of sand to clay in the upper soil is >1.0 but <13; or the weighted average percentage of organic carbon in the upper soil to a depth of 18 cm is not as much as one-fifth more than the values just stated if a duripan is present at a depth <40 cm but >18 cm;

d. Do not have an argillic horizon that has 35 percent or more clay in some part and also has either

(1) An increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon; or

(2) An increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon; and

e. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher.

Abruptic Durargids are like Typic Durargids except for *d.*

Abruptic Xerollic Durargids are like Typic Durargids except for *c, d,* and *e.* They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Haplic Durargids are like Typic Durargids except for *b.*

Haploxerollic Durargids are like Typic Durargids except for *b* and *c,* with or without *e.* They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Xerollic Durargids are like Typic Durargids except for *c,* with or without *e.* They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Haplargids

Distinctions between Typic Haplargids and other subgroups

Typic Haplargids are the Haplargids that

a. Are not saturated with water for 90 consecutive days or more within 1 m of the surface in most years and do not have any of the following characteristics within a depth of 1 m below the surface if there is ground water within this depth at some time in most years:

(1) Dominant chroma of 1 or less throughout and a hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have texture finer than loamy fine sand in some subhorizon above a depth of 50 cm;

c. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more (by volume) durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

d. Do not have a lithic contact within 50 cm of the surface;

e. Have a weighted average percentage of organic carbon in the upper 40 cm that is <0.6 percent if the weighted average ratio of sand to clay in the soil above that depth is 1.0 or less, or is less than one-seventh percent if the ratio is 13 or more, or have an intermediate percentage of organic carbon if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the soil to a depth of 18 cm that is not as much as one-fifth more than the values just stated if there is a lithic or paralithic contact at a depth <40 cm but >18 cm;

f. Have an argillic horizon that is continuous throughout the area of each pedon;

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface, to the base of an Ap horizon, or to the top of the argillic horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

h. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature is 5°C or higher at a depth of 50 cm.

Aquic Haplargids are like Typic Haplargids except for *a*, with or without *e* or *h*, or both.

Arenic Haplargids are like Typic Haplargids except for *b*.

Arenic Ustalfic Haplargids are like Typic Haplargids except for *b* and *h*. They have a mean annual soil temperature of 8°C or higher and an aridic moisture regime that borders on an ustic regime.

Arenic Ustollic Haplargids are like Typic Haplargids except for *b* and *e*, with or without *h*. They have a mean annual soil temperature of 8°C or higher and an aridic moisture regime that borders on an ustic regime.

Borollic Haplargids are like Typic Haplargids except for *e*, with or without *h*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. Their aridic moisture regime borders on an ustic regime.

Borollic Lithic Haplargids are like Typic Haplargids excpet for *d* and *e*, with or without *h*. They have a frigid temperature regime and an aridic moisture regime that borders on an ustic regime.

Borollic Vertic Haplargids are like Typic Haplargids except for *e* and *g*, with or without *h*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Duric Haplargids are like Typic Haplargids except for *c*.

Durixerollic Haplargids are like Typic Haplargids except for *c* and *e*, with or without *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The aridic moisture regime borders on a xeric regime.

Lithic Haplargids are like Typic Haplargids except for *d*.

Lithic Ruptic-Entic Xerollic Haplargids are like Typic Haplargids except for *d*, *e*, and *f*, with or without *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The aridic moisture regime borders on a xeric regime.

Lithic Ustollic Haplargids are like Typic Haplargids except for *d* and *e*, with or without *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Lithic Xerollic Haplargids are like Typic Haplargids except for *d* and *e*, with or without *h*. They have a mean annual soil temperature that is lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustalfic Haplargids are like Typic Haplargids except for *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Ustertic Haplargids are like Typic Haplargids except for *g*, with or without *e* or *h*, or both. They have cracks that remain open from 175 to 240 days, cumulative, in most years and that are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid. Other frigid soils are excluded.

Ustollic Haplargids are like Typic Haplargids except for *e*, with or without *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Vertic Haplargids are like Typic Haplargids except for *g* or for *g* and *h* and have cracks that remain open for 8 months or more, cumulative, in most years.

Xeralfic Haplargids are like Typic Haplargids except for *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerertic Haplargids are like Typic Haplargids except for *g* or *e* and *g* and have a thermic, mesic, or frigid soil temperature regime, and they have cracks that close for 60 consecutive days or more during the 120 days following the winter solstice in more than 7 out of 10 years.

Xerollic Haplargids are like Typic Haplargids except for *e* with or without *h*, have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Nadurargids

Distinctions between Typic Nadurargids and other subgroups

Typic Nadurargids are the Nadurargids that

a. Are not saturated with water in any horizon within a depth of 1 m at any period or do not have either of the following characteristics within the horizon or horizons that are saturated:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Both a dominant chroma of 2 or less and mottles that are not due to segregated lime;

b. Have a platy or massive duripan that is indurated in some subhorizon; and

c. Have a duripan shallower than 18 cm; or have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average ratio of sand to clay to that depth is 1.0 or less, or that is less than one-seventh percent if the ratio of sand to clay is 13 or more, or have an intermediate amount of organic carbon if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a duripan that is shallower than 40 cm but deeper than 18 cm.

Aquic Haplic Nadurargids are like Typic Nadurargids except for *a* and *b*, with or without *c*.

Haplic Nadurargids are like Typic Nadurargids except for *b*.

Haploxerollic Nadurargids are like Typic Nadurargids except for *b* and *c*. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Nadurargids are like Typic Nadurargids except for *c*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil tempera-

tures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Natrargids

Distinctions between Typic Natrargids and other subgroups

Typic Natrargids are the Natrargids that

a. Either are not saturated with water in any horizon within 1 m of the surface at any time or do not have either of the following characteristics in the horizon or horizons that are saturated:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part; or

(2) Both a dominant chroma of 2 or less accompanied by mottles that are not due to segregated lime;

b. Do not have a horizon within 1 m of surface that is more than 15 cm thick and that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have more than 10 percent of the ped surfaces deeper than 2.5 cm below the upper boundary of the natric horizon covered by skeletans;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average of sand to clay in that depth is 1.0 or less, or is not more than one-seventh percent if the ratio is 13 or more, or has an intermediate percentage of organic carbon if the ratio is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a lithic or paralithic contact that is shallower than 40 cm but deeper than 18 cm; and

f. Have an SAR of ≥ 13 or have 15 percent or more saturation with sodium throughout the major part of the natric horizon.

Aquic Natrargids are like Typic Natrargids except for *a* or for *a* and *e*.

Borollic Natrargids are like Typic Natrargids except for *e* or for *e* and *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥ 5° C, and the moisture regime is aridic bordering on ustic.

Borollic Glossic Natrargids are like Typic Natrargids except for *c* and *e*, with or without *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on ustic.

Duric Natrargids are like Typic Natrargids except for *b* or for *b* and *f*.

Durixerollic Natrargids are like Typic Natrargids except for *b* and *e*. They have a mean annual soil temperature lower than 22° C. The mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more,

and the moisture regime is aridic bordering on xeric.

Glossic Ustollic Natrargids are like Typic Natrargids except for *c* and *e*, with or without *f*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on ustic.

Haplic Natrargids are like Typic Natrargids except for *f*.

Haploxerollic Natrargids are like Typic Natrargids except for *e* and *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Haplustollic Natrargids are like Typic Natrargids except for *e* and *f*. They have a mean annual soil temperature of 8° C or higher, and the moisture regime is aridic but borders on ustic.

Lithic Natrargids are like Typic Natrargids except for *d*.

Lithic Xerollic Natrargids are like Typic Natrargids except for *d* and *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustollic Natrargids are like Typic Natrargids except for *e*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Natrargids are like Typic Natrargids except for *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The moisture regime is aridic, bordering on xeric.

Paleargids

Distinctions between Typic Paleargids and other subgroups

Typic Paleargids are the Paleargids that

a. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

b. Have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm of <0.6 percent if the weighted average ratio of sand to clay above this depth is 1.0 or less, or one-seventh percent if the ratio is 13 or more, or an intermediate percentage of organic carbon if the ratio of sand to clay is between 1.0 and 13; or a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a petrocalcic horizon whose upper boundary is shallower than 40 cm but deeper than 18 cm;

c. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface;

d. Have either

(1) An increase of 15 percent or more clay (absolute)

IDS

within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon, or

(2) An increase of 10 percent or more clay (absolute) if the soil is cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface, to the base of an Ap horizon, or to the top of the argillic horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

f. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher.

Borollic Paleargids are like Typic Paleargids except for *b* or for *b* and *f*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by $\geq$5° C. They have an aridic moisture regime that borders on an ustic regime.

Borollic Vertic Paleargids are like Typic Paleargids except for *b* and *e*, with or without *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by $\geq$5° C, and the cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Petrocalcic Paleargids are like Typic Paleargids except for *c* or for *c* and *d*.

Petrocalcic Ustalfic Paleargids are like Typic Paleargids except for *c* and *f*, with or without *d*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Petrocalcic Ustollic Paleargids are like Typic Paleargids except for *b* and *c*, with or without *d* or *f*, or both. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Petrocalcic Xerollic Paleargids are like Typic Paleargids except for *b* and *c*, with or without *d* or *f*, or both. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustollic Paleargids are like Typic Paleargids except for *b* or for *b* and *f*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xeralfic Paleargids are like Typic Paleargids except for *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Paleargids are like Typic Paleargids except for *b*, with or without *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

ORTHIDS

Key to great groups

EBA. Orthids that have a salic horizon whose upper boundary is within 75 cm of the soil surface and are saturated with water within a depth of 1 m for 1 month or more in most years or have artificial drainage and lack a duripan that has an upper boundary within 1 m of the soil surface.

Salorthids, p. 106

EBB. Other Orthids that have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface and is not overlain by a duripan.

Paleorthids, p. 105

EBC. Other Orthids that have a duripan whose upper boundary is within 1 m of the soil surface.

Durorthids, p. 103

EBD. Other Orthids that have a gypsic or petrogypsic horizon whose upper boundary is within 1 m of the soil surface.

Gypsiorthids, p. 104

EBE. Other Orthids that have a calcic horizon whose upper boundary is within 1 m of the surface and that are calcareous in all parts above the calcic horizon after the upper soil, to a depth of 18 cm, is mixed unless the texture is as coarse or coarser than loamy fine sand.

Calciorthids, p. 99

EBF. Other Orthids (that have a cambic horizon).

Camborthids, p. 101

Calciorthids

Distinctions between Typic Calciorthids and other subgroups

Typic Calciorthids are the Calciorthids that

a. Are not saturated with water for 90 consecutive days or more in most years within 1 m of the surface and do not have any of the following characteristics within a depth of 1 m below the surface if the soil above that depth is saturated with water at some period in most years or the soil is artificially drained:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and 50 cm than in the saturated zone;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
c. Do not have a lithic contact within 50 cm of the surface;
d. Have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay for this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13; or a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a lithic or paralithic contact that is shallower than 40 cm but deeper than 18 cm;
e. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature is 5° C or higher at a depth of 50 cm; and
f. Do not have reddish peds below the calcic horizon that are weakly calcareous or noncalcareous but that are thickly coated with lime.

Aquic Calciorthids are like Typic Calciorthids except for *a,* with or without *d* or *e,* or both.

Aquic Duric Calciorthids are like Typic Calciorthids except for *a* and *b,* with or without *d* or *e,* or both.

Argic Calciorthids are like Typic Calciorthids except for *f.*

Borollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e.* The soil temperature regime is frigid, and the moisture regime is aridic but borders on ustic.

Borollic Lithic Calciorthids are like Typic Calciorthids except for *c* and *d,* with or without *e.* The soil temperature regime is frigid, and the moisture regime is aridic but borders on ustic.

Durixerollic Calciorthids are like Typic Calciorthids except for *b* and *d,* with or without *e,* and have a mean annual soil temperature lower than 22° C. The mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and the moisture regime is aridic but borders on xeric.

Lithic Calciorthids are like Typic Calciorthids except for *c.*

Lithic Ustollic Calciorthids are like Typic Calciorthids except for *c* and *d,* with or without *e.* They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Lithic Xerollic Calciorthids are like Typic Calciorthids except for *c* and *d,* with or without *e.* They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Ustochreptic Calciorthids are like Typic Calciorthids except for *e.* They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic moisture regime.

Ustollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e*. They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Cambiorthids

Distinctions between Typic Camborthids and other subgroups

Typic Camborthids are the Camborthids that

a. Are not saturated with water for 90 consecutive days or more within 1 m of the surface in most years and do not have any of the following characteristics within 1 m of the soil surface if the soil of that zone is saturated with water at some period in most years or the soil is artificially drained:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part,

(2) Dominant chroma of 2 or less and mottles that are due to segregation of iron or manganese, or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and a depth of 50 cm than in the saturated zone;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have a lithic contact within 50 cm of the surface;

d. Have a weighted average organic-carbon content in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or an intermediate weighted average percentage of organic carbon if the ratio is between 1.0 and 13; or a weighted average percentage of organic carbon in the upper soil to a depth of 18 cm that is not as much as one-fifth more than the values just stated if there is a lithic or paralithic contact shallower than 40 cm but deeper than 18 cm;

e. Are dry in all parts of the moisture control section for more than three-fourths of the time (cumulative) that the soil temperature is 5° C or more at a depth of 50 cm unless the soil is irrigated;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in

the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m, and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

g. Have a content of organic carbon that decreases regularly with depth below a depth of 25 cm and, unless a lithic or paralithic contact occurs at a shallower depth, reaches a level of <0.2 percent at a depth 1.25 m below the surface;

h. Have an SAR of 45 or less or <40 percent saturation with sodium throughout the cambic horizon if the saturated hydraulic conductivity is slow or very slow; and

i. Do not have an anthropic epipedon.

Anthropic Camborthids are like Typic Camborthids except for *d* and *i.*

Aquic Camborthids are like Typic Camborthids except for *a,* with or without *d* or *e,* or both.

Aquic Duric Camborthids are like Typic Camborthids except for *a* and *b,* with or without *d* or *e,* or both.

Borollic Camborthids are like Typic Camborthids except for *d* or for *d* and *e.* The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on an ustic regime.

Borollic Lithic Camborthids are like Typic Camborthids except for *c* and *d,* with or without *e.* The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on ustic.

Borollic Vertic Camborthids are like Typic Camborthids except for *d* and *f,* with or without *e.* The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C. The cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Duric Camborthids are like Typic Camborthids except for *b.*

Durixerollic Camborthids are like Typic Camborthids except for *b* and *d,* with or without *e.* They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Durixerollic Lithic Camborthids are like Typic Camborthids except for *b, c,* and *d,* with or without *e.* They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Fluventic Camborthids are like Typic Camborthids except for *g.*

Lithic Camborthids are like Typic Camborthids except for *c.*

Lithic Xerollic Camborthids are like Typic Camborthids except for *c* and *d,* with or without *e.* They have a mean

annual soil temperature lower than 22°C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more. They have an aridic moisture regime that borders on a xeric regime.

Natric Camborthids are like Typic Camborthids except for *h,* with or without any or all of *a, d, e, f,* and *g,* and they have slow or very slow saturated hydraulic conductivity.

Ustertic Camborthids are like Typic Camborthids except for *f,* with or without any or all of *d, e,* and *g.* In most years, unless irrigated, they have cracks that remain open for 175 to 240 days, cumulative. The cracks are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid.

Ustochreptic Camborthids are like Typic Camborthids except for *e.* They have an aridic moisture regime that borders on an ustic moisture regime and a hyperthermic, thermic, or mesic soil temperature regime.

Ustollic Camborthids are like Typic Camborthids except for *d* or for *d* and *e,* have a mean annual soil temperature that is 8°C or higher, and have an aridic moisture regime that borders on an ustic regime.

Vertic Camborthids are like Typic Camborthids except for *f* or for *e* and *f.* Unless the soils are irrigated, the cracks remain open in most years for more than 240 days, cumulative, and are not closed in most years for as many as 60 consecutive days at any season.

Xerertic Camborthids are like Typic Camborthids except for *f,* with or without any or all of *d, e,* and *g.* They have a thermic, mesic, or frigid soil temperature regime and have cracks that are closed for 60 consecutive days or more during the 120 days following the winter solstice in more than 7 years out of 10.

Xerollic Camborthids are like Typic Camborthids except for *d* or for *d* and *e.* They have a mean annual soil temperature lower than 22°C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more. They have an aridic moisture regime that borders on a xeric regime.

Durorthids

Distinctions between Typic Durorthids and other subgroups

Typic Durorthids are the Durorthids that

a. Are not saturated with water for 90 consecutive days or more in most years within 1 m of the surface and do not have a subhorizon within 1 m of the soil surface that has the following characteristics if the horizon is saturated with water at some period in most years or the soil is artifically drained:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less accompanied by mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater

SAR (or percentage of exchangeable sodium) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have a platy or massive duripan that is indurated in some subhorizon;

c. Have a duripan whose upper boundary is shallower than 18 cm; or have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average ratio of sand to noncarbonate clay above that depth is 1.0 or less or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13; or a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a duripan shallower than 40 cm but deeper than 18 cm; and

d. Are dry in all parts of the moisture control section for more than three-fourths of the time that the soil temperature at a depth of 50 cm is 5°C or higher.

Aquentic Durorthids are like Typic Durorthids except for *a* and *b*, with or without *c* or *d*, or both.

Aquic Durorthids are like Typic Durorthids except for *a*, with or without *c* or *d*, or both.

Entic Durorthids are like Typic Durorthids except for *b*.

Haploxerollic Durorthids are like Typic Durorthids except for *b* and *c*, with or without *d*. They have a mean annual soil temperature lower than 22°C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Durorthids are like Typic Durorthids except for *c* or for *c* and *d*. They have a mean annual soil temperature lower than 22°C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more. They have an aridic moisture regime that borders on a xeric regime.

Gypsiorthids

Distinctions between Typic Gypsiorthids and other subgroups

Typic Gypsiorthids are the Gypsiorthids that

a. Do not have a petrogypsic horizon whose upper boundary is within 1 m of the soil surface; and

b. Have a gypsic horizon in which the product of the percentage of gypsum and the thickness in centimeters above a depth of 1.5 m is 3,000 or more.

Calcic Gypsiorthids are like Typic Gypsiorthids except for *b* and have a calcic horizon above the gypsic horizon.

Cambic Gypsiorthids are like Typic Gypsiorthids except for *b* and do not have a calcic horizon above the gypsic horizon.

Petrogypsic Gypsiorthids are like Typic Gypsiorthids except for *a* with or without *b*.

Paleorthids

Distinctions between Typic Paleorthids and other subgroups

Typic Paleorthids are the Paleorthids that

a. Are not saturated with water for 90 consecutive days or more in most years within 1 m below the soil surface and do not have a subhorizon that has the following characteristics within 1 m of the surface if the horizon is saturated with water at some period in most years or the soil is artificially drained. The soils do not have:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have a petrocalcic horizon whose upper boundary is shallower than 18 cm, or have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a petrocalcic horizon that is shallower than 40 cm but deeper than 18 cm; and

c. Are dry in all parts of the moisture control section for more than three-fourths of the time (cumulative) that the soil temperature is 5°C or higher at a depth of 50 cm.

Aquic Paleorthids are like Typic Paleorthids except for *a*, with or without *b* or *c*, or both.

Ustochreptic Paleorthids are like Typic Paleorthids except for *c*. They have a mesic, thermic, or hyperthermic soil temperature regime and an aridic moisture regime that borders on an ustic regime.

Ustollic Paleorthids are like Typic Paleorthids except for *b* or for *b* and *c*. They have a mean annual soil temperature that is 8°C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Paleorthids are like Typic Paleorthids except for *b* or for *b* and *c*. They have a mean annual soil temperature lower than 22°C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more. They have an aridic moisture regime that borders on a xeric regime.

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Salorthids

Distinctions between Typic Salorthids and Aquollic Salorthids

Typic Salorthids are the Salorthids that

a. Have a salic horizon that has its upper boundary within 18 cm of the soil surface; and

b. Have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13.

Aquollic Salorthids are like Typic Salorthids except for *b*.

[1] A duripan or a petrocalcic horizon must have its upper boundary within 1 m of the surface to be diagnostic in Aridisols.

Chapter 7
Entisols

Key to suborders

JA. Entisols that

1. Have sulfidic materials within 50 cm of the mineral soil surface; or

2. Are permanently saturated with water and have in all horizons below 25 cm

a. Dominant hue that is neutral or bluer than 10Y and

b. Colors that change on exposure to the air; or

3. Are saturated with water at some time of year or are artificially drained and have, within 50 cm of the surface, dominant color (moist) in the matrix as follows:

a. In horizons that have texture finer than loamy fine sand in some or all subhorizons, or that have >35 percent (by volume) of rock fragments in some subhorizon

(1) If there is mottling, chroma is 2 or less;

(2) If there is no mottling and the value is less than 4, chroma is less than 1; if the value is 4 or more, chroma is 1 or less;

b. In horizons that have texture of loamy fine sand or coarser in all subhorizons

(1) If the hue is as red or redder than 10YR and there is mottling, chroma is 2 or less; if there is no mottling and the value is less than 4, chroma is less than 1; or if the value is 4 or more, chroma is 1 or less;

(2) If the hue is between 10YR and 10Y and there is distinct or prominent mottling, chroma is 3 or less; if there is no mottling, chroma is 1 or less;

(3) Hue is bluer than 10Y; or

(4) Any color if the color is due to uncoated grains of sand.

Aquents, p. 107

JB. Other Entisols that have fragments of diagnostic horizons between 25 cm and 1 m below the surface, but the fragments are not arranged in discernible order.

Arents, p. 112

JC. Other Entisols that have below the Ap horizon or below a depth of 25 cm, whichever is deeper, <35 percent (by volume) of rock fragments and that have texture of loamy fine sand or coarser in all subhorizons[1] either to a depth of 1 m or to a lithic, paralithic, or petroferric contact, whichever is shallower.

Psamments, p. 120

JD. Other Entisols that do not have a lithic or paralithic contact within 25 cm of the soil surface and that have slopes of <25 percent and organic-carbon content that decreases irregularly with depth or remains above a level of 0.2 percent to a depth of 1.25 m, and the mean annual soil temperature is higher than 0°C. (Strata of sand or loamy sand may have less organic carbon if finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more).

Fluvents, p. 112

JE. Other Entisols.

Orthents, p. 116

AQUENTS

Key to great groups

JAA. Aquents that have sulfidic materials within 50 cm of the mineral soil surface.

Sulfaquents, p. 111

ENT

JAB. Other Aquents that have an n value of >0.7 and that have at least 8 percent clay in all subhorizons between a depth of 20 and 50 cm and that have a mean annual soil temperature higher than 0°C.

Hydraquents, p. 110

JAC. Other Aquents that have a cryic but not a pergelic[2] soil temperature regime.

Cryaquents, p. 108

JAD. Other Aquents that have an organic-carbon content[3] that decreases irregularly with depth or that remains above 0.2 percent to a depth of 1.25 m; and that have texture finer than loamy fine sand in some or all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and 1 m or a lithic or paralithic contact, whichever is shallower. Thin strata of sand may have less organic carbon if the finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more.

Fluvaquents, p. 108

JAE. Other Aquents that have a difference of <5°C between the mean summer and mean winter soil temperatures at a depth of 50 cm.

Tropaquents, p. 112

JAF. Other Aquents that have a sandy particle-size class in all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and 1 m or a lithic or paralithic contact, whichever is shallower, and that have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5°C or more.

Psammaquents, p. 111

JAG. Other Aquents.

Haplaquents, p. 110

Cryaquents

Distinctions between Typic Cryaquents and other subgroups

Typic Cryaquents are the Cryaquents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density of the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or

(2) A ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andaqueptic Cryaquents are like Typic Cryaquents except for *a.*

Fluvaquents

Distinctions between Typic Fluvaquents and other subgroups

Typic Fluvaquents are the Fluvaquents that

a. Have, in 60 percent or more of the matrix in all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and a depth of 75 cm, one or more of the following:

(1) If mottled and

(a) If the hue is 2.5Y or redder[4] and the value, moist, is more than 5, the chroma, moist, is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less; or

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less; or

(2) The chroma, moist, is 1 or less and mottles may or may not be present;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 grams per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

d. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is <3.5;

e. Do not have a buried Histosol or a buried histic epipedon that has its upper boundary within 1 m of the soil surface;

f. Do not have sulfidic materials within 1 m of the mineral soil surface; and

g. Have a difference of 5°C or more between the mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower;

Aeric Fluvaquents are like Typic Fluvaquents except for *a* or *a* and *b*.

Aeric Tropic Fluvaquents are like Typic Fluvaquents except for *a* and *g*, with or without *d*.

Andaqueptic Fluvaquents are like Typic Fluvaquents except for *b*.

Humaqueptic Fluvaquents are like Typic Fluvaquents except for *d*, and the base saturation (by NH_4OAc) is <50 percent in some horizon and does not increase to 50 percent or more within a depth of 1 m below the soil surface.

Mollic Fluvaquents are like Typic Fluvaquents except for *d*, and the base saturation (by NH_4OAc) is 50 percent or more throughout the soil or increases to 50 percent or more within a depth of 1 m below the soil surface.

Sulfic Fluvaquents are like Typic Fluvaquents except for *f*.

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Thapto-Histic Fluvaquents are like Typic Fluvaquents except for *e* with or without *a* or *d* or both.

Thapto-Histic Tropic Fluvaquents are like Typic Fluvaquents except for *e* and *g*, with or without *d*.

Tropic Fluvaquents are like Typic Fluvaquents except for *g* or for *g* and *d*.

Vertic Fluvaquents are like Typic Fluvaquents except for *c*, with or without *a* or *d*, or both, and the cracks are not open permanently.

Haplaquents

Distinctions between Typic Haplaquents and other subgroups

Typic Haplaquents are the Haplaquents that

a. Have in 60 percent or more of the matrix in all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and 75 cm one or more of the following:

(1) If mottled and

(a) If the hue is 2.5Y or redder[5] and the value, moist, is more than 5, the chroma, moist, is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less; or

(2) The chroma, moist, is 1 or less and mottles may or may not be present;

b. Have an Ap horizon that has a color value, moist, of 4 or more or that has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is $<$15 cm thick if its color value, moist, is less than 3.5;

c. Do not have a lithic contact within 50 cm of the soil surface; and

d. Do not have sulfidic materials within 1 m of the mineral soil surface.

Aeric Haplaquents are like Typic Haplaquents except for *a* or *a* and *b*.

Mollic Haplaquents are like Typic Haplaquents except for *b*.

Sulfic Haplaquents are like Typic Haplaquents except for *d*.

Hydraquents

Definition

Hydraquents are the Aquents that do not have sulfidic materials within 50 cm of the mineral soil surface and

1. Have a mean annual soil temperature higher than 0° C;

2. In all subhorizons between 20 and 50 cm below the mineral surface have both an *n* value of more than 0.7 and at least 8 percent clay; and

3. Have texture that is loamy very fine sand or finer in some horizon below the Ap horizon or a depth of 25 cm, whichever is deeper, but above a depth of 1 m or a lithic or

a paralithic contact, whichever is shallower.

The Hydraquents have been little used or studied in the United States, and subgroups have not been developed. The typic subgroup could be defined as having a high *n* value, 1 or more, in all subhorizons between a depth of 20 cm and 1 m. Hydraquents that have *n* values <1 in the upper 25 cm or more could be Haplic Hydraquents, which are intergrades to Haplaquents. Thapto-Histic Hydraquents, which have a buried Histosol or histic epipedon whose upper boundary is within a depth of 1 m, doubtless exist. Hydraquents that have a small amount of sulfides or none in the upper horizons can be drained and cultivated. A sulfic subgroup might be useful for those soils that, after drainage, have a pH <4.5 (1:1 water) in the upper 25 cm or more, those that have enough sulfides in the undrained soil to produce this pH on drainage, and those that have a larger amount of sulfides at a depth between 50 cm and 1 m. A large amount of sulfides at a depth below 1 m should be noted but could be shown as a phase.

Psammaquents

Distinctions between Typic Psammaquents and other subgroups

Typic Psammaquents are the Psammaquents that

a. Do not have a lithic contact within 50 cm of the soil surface;

b. Have an Ap horizon that has a color value, moist, of 4 or more or has a value, dry, of 6 or more when crushed and smoothed (smoothed with a knife to eliminate shadows), or the A1 horizon is less than 15 cm thick if its color value, moist, is lower than 3.5; and

c. Do not have an albic horizon at the surface or immediately under an A1 or Ap horizon that, in turn, is underlain by another horizon that has a color value more than one unit darker or that has chroma of 6 or more.

Humaqueptic Psammaquents are like Typic Psammaquents except for *b*, and their base saturation (by NH_4OAc) is <50 percent in more than half the thickness of the subhorizons within the upper 1 m.

Lithic Psammaquents are like Typic Psammaquents except for *a*.

Mollic Psammaquents are like Typic Psammaquents except for *b*, and their base saturation (by NH_4OAc) is 50 percent or more in more than half the thickness of the subhorizons within the upper 1 m.

Spodic Psammaquents are like Typic Psammaquents except for *c*.

Sulfaquents

Definition of Typic Sulfaquents

Typic Sulfaquents are the Sulfaquents that

a. Have sulfidic materials within 50 cm of the mineral soil surface if the *n* value is ≥ 1 or within 30 cm if the *n* value is <1.

Tropaquents

Definition

The definition of the great group of Tropaquents that follows cannot be tested in the United States and is provisional.

Tropaquents are the Aquents that

1. Have an isomesic or warmer iso temperature regime;
2. Have an *n* value of 0.7 or less or have <8 percent clay in some subhorizon between 20 and 50 cm; and
3. Have an organic-carbon content[6] that decreases regularly with depth below 25 cm and reaches a level of 0.2 percent or less within a depth of 1.25 m.

Subgroups have not been defined.

ARENTS

The Arents form a unique suborder in that not only are no great groups recognized, but also there is no typic subgroup. Subgroups of Arents are intergrades to suborders or great groups of Spodosols, Alfisols, or other orders, according to the nature of the fragments that can be identified and according to the soil moisture and soil temperature regimes of the suborders.

FLUVENTS

Key to great groups

JDA. Fluvents that have a cryic soil temperature regime.
Cryofluvents, p. 112

JDB. Other Fluvents that have a xeric moisture regime.
Xerofluvents, p. 115

JDC. Other Fluvents that have an ustic moisture regime.
Ustifluvents, p. 115

JDD. Other Fluvents that have a torric moisture regime.
Torrifluvents, p. 113

JDE. Other Fluvents that have an isomesic, isothermic, or isohyperthermic temperature regime.
Tropofluvents, p. 114

JDF. Other Fluvents.
Udifluvents, p. 114

Cryofluvents

Distinctions between Typic Cryofluvents and other subgroups

Typic Cryofluvents are the Cryofluvents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exhange

acidity than the sum of bases plus KCl-extractable aluminum;
b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface; and
c. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5.

Andeptic Cryofluvents are like Typic Cryofluvents except for *a*.

Aquic Cryofluvents are like Typic Cryofluvents except for *b* or for *b* and *c*.

Mollic Cryofluvents are like Typic Cryofluvents except for *c*.

Torrifluvents

Distinctions between Typic Torrifluvents and other subgroups

Typic Torrifluvents are the Torrifluvents that
a. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains as much as 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
b. Do not have all three of the following characteristics:
(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;
(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness within the upper 1 m;
c. Do not have an anthropic epipedon; and
d. Are dry in all parts of the moisture control section three-fourths or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5°C or more.

Anthropic Torrifluvents are like Typic Torrifluvents except for *c*.

Durorthidic Torrifluvents are like Typic Torrifluvents except for *a*.

Durorthidic Xeric Torrifluvents are like Typic Torrifluvents except for *a* and *d*. They have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on a xeric regime.

Ustertic Torrifluvents are like Typic Torrifluvents except for *b*, with or without *d*. Unless the soils are irrigated, the cracks remain open in most years from 175 to 240 days, cumulative, and are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid.

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Ustic Torrifluvents are like Typic Torrifluvents except for *d,* and they have a torric moisture regime that borders on an ustic regime.

Vertic Torrifluvents are like Typic Torrifluvents except for *b,* with or without *c* or *d* or both. Unless the soils are irrigated, the cracks remain open in most years for more than 240 days, cumulative, and are not closed for as many as 60 consecutive days at any season in most years.

Xeric Torrifluvents are like Typic Torrifluvents except for *d,* and they have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on a xeric regime.

Tropofluvents

Definition

Tropofluvents are the Fluvents that

1. Have an isomesic or warmer iso temperature regime; and

2. Have a udic moisture regime.

Only one series of Tropofluvents has been recognized in the United States, and subgroups have not been defined. It is suggested that the definition of the typic subgroup should parallel that of Typic Udifluvents in the great group that is defined next.

Udifluvents

Distinctions between Typic Udifluvents and other subgroups

Typic Udifluvents are the Udifluvents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. Do not have mottles within 50 cm of the surface that have chroma of 2 or less or, at a depth between 50 cm and 1 m, do not have any horizons that are saturated with water at some period or that are artificially drained and have chroma less than 1 or hue bluer than 10Y and value, moist, of 4 or more; and

c. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5.

Aquic Udifluvents are like Typic Udifluvents except for *b* or for *b* and *c.*

Mollic Udifluvents are like Typic Udifluvents except for *c.*

Ustifluvents

Distinctions between Typic Ustifluvents and other subgroups

Typic Ustifluvents are the Ustifluvents that

a. Do not have mottles within 50 cm of the surface that have chroma of 2 or less and do not have, at a depth within 1.5 m of the surface, a horizon that is saturated with water at some period or is artificially drained and that has chroma less than 1 or a hue bluer than 10Y; and

b. Do not have the following combination of characteristics:

(1) Cracks at some period in most years, when the soil is not irrigated, that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

c. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5

Aquic Ustifluvents are like Typic Ustifluvents except for *a* or for *a* and *c*.

Mollic Ustifluvents are like Typic Ustifluvents except for *c*.

Vertic Ustifluvents are like Typic Ustifluvents except for *b* or for *b* and *a*.

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Xerofluvents

Distinctions between Typic Xerofluvents and other subgroups

Typic Xerofluvents are the Xerofluvents that

a. Are not saturated with water within 1.5 m of the surface during any period in most years;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or that is brittle and has firm consistence when moist;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in

the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

d. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5.

Aquic Xerofluvents are like Typic Xerofluvents except for *a* or for *a* and *d.*

Aquic Durorthidic Xerofluvents are like Typic Xerofluvents except for *a* and *b* with or without *d.*

Mollic Xerofluvents are like Typic Xerofluvents except for *d.*

Vertic Xerofluvents are like Typic Xerofluvents except for *c* or for *c* and *a.*

ORTHENTS

Key to great groups

JEA. Orthents that have a cryic or pergelic temperature regime.

Cryorthents, p. 116

JEB. Other Orthents that have a torric moisture regime or that have a conductivity of the saturation extract that is 2 mmho per centimeter or greater at 25°C in some part above whichever of the following depths is the least: a lithic or paralithic contact or 1.25 m if particle-size class[7] is sandy, 90 cm if loamy, and 75 cm if clayey.

Torriorthents, p. 117

JEC. Other Orthents that have a xeric moisture regime.

Xerorthents, p. 120

JED. Other Orthents that have a udic moisture regime and mean summer and mean winter soil temperatures at a depth of 50 cm that differ by <5°C.

Troporthents, p. 118

JEE. Other Orthents that have a udic moisture regime.

Udorthents, p. 119

JEF. Other Orthents.

Ustorthents, p. 119

Cryorthents

Distinctions between Typic Cryorthents and other subgroups

Typic Cryorthents are the Cryorthents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density in the fine-earth fraction (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a mean annual soil temperature that is higher than 0° C; and
e. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness.[8]

Alfic Andeptic Cryorthents are like Typic Cryorthents except for *a* and *e*.

Andeptic Cryorthents are like Typic Cryorthents except for *a*.

Aquic Cryorthents are like Typic Cryorthents except for *b*.

Lithic Cryorthents are like Typic Cryorthents except for *c*, with or without *d*.

Pergelic Cryorthents are like Typic Cryorthents except for *d*, with or without *a* or *b*, or both.

Torriorthents

Distinctions between Typic Torriorthents and other subgroups

Typic Torriorthents are the Torriorthents that
a. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
b. Do not have a lithic contact within 50 cm of the surface;
c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or the base of an Ap horizon;
(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness;

d. Are dry in all parts of the moisture control section three-fourths or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher; and
e. Are not saturated with water within 1.5 m of the surface at any time of year in most years.

Aquic Torriorthents are like Typic Torriorthents except for *e* or for *d* and *e*.

Aquic Durorthidic Torriorthents are like Typic Torriorthents except for *a* and *e*, or for *a*, *d*, and *e*.

Durorthidic Torriorthents are like Typic Torriorthents except for *a*.

Durorthidic Xeric Torriorthents are like Typic Torriorthents except for *a* and *d*. They have a thermic, mesic, or frigid soil temperature regime and have a torric moisture regime that borders on a xeric regime.

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Lithic Torriorthents are like Typic Torriorthens except for *b*.

Lithic Ustic Torriorthents are like Typic Torriorthents except for *b* and *d*. They either (1) have a hyperthermic or an iso soil temperature regime or (2) have a thermic or mesic soil temperature regime and have a torric moisture regime that borders on an ustic regime.

Lithic Xeric Torriothents are like Typic Torriorthents except for *b* and *d*. They have a thermic, mesic, or frigid soil temperature regime and an aridic moisture regime that borders on a xeric regime.

Ustertic Torriorthents are like Typic Torriorthents except for *c*, with or without *d* or *e*, or both. Unless irrigated, they have cracks that remain open from 175 to 240 days, cumulative, and are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid.

Ustic Torriorthents are like Typic Torriorthents except for *d*. They either (1) have a hyperthermic or an iso soil temperature regime or (2) have a thermic, mesic, or a frigid soil temperature regime and have an aridic moisture regime that borders on an ustic regime.

Vertic Torriorthents are like Typic Torriorthents except for *c* or for *c* and *d*. Unless the soil is irrigated, the cracks remain open in most years for more than 240 days, cumulative, and are not closed in most years for as many as 60 consecutive days at any season.

Xerertic Torriorthents are like Typic Torriorthents except for *c*, with or without *d* or *e*, or both. They have a thermic, mesic, or frigid soil temperature regime and have cracks that are closed for 60 consecutive days or more during the 120 days following the winter solstice in more than 7 years out of 10.

Xeric Torriorthents are like Typic Torriorthents except for *d*. They have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on a xeric regime.

Troporthents

Distinctions between Typic Troporthents and other subgroups

Typic Troporthents are the Troporthents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum; and

b. Do not have a lithic contact within 50 cm of the soil surface.

Andeptic Troporthents are like Typic Troporthents except for *a*.

Lithic Troporthents are like Typic Troporthents except for *b*.

Udorthents

Distinctions between Typic Udorthents and other subgroups

Typic Udorthents are the Udorthents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

b. Are not saturated with water for as long as 1 month within 1.5 m of the surface;

c. Do not have a lithic contact within 50 cm of the surface; and

d. Have <50 percent by volume of wormholes, wormcasts, and filled animal burrows between the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, and either a depth of 1 m or a lithic or paralithic contact if one is present above a depth of 1 m.

Andeptic Udorthents are like Typic Udorthents except for *a*.

Aquic Udorthents are like Typic Udorthents except for *b*.

Lithic Udorthents are like Typic Udorthents except for *c* or for *c* and *d*.

Vermic Udorthents are like Typic Udorthents except for *d*.

Ustorthents

Distinctions between Typic Ustorthents and other subgroups

Typic Ustorthents are the Ustorthents that

a. Are not saturated with water within 1.5 m of the surface for as long as 1 month in most years;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have a lithic contact within 50 cm of the surface;

d. Have <50 percent (by volume) wormholes, wormcasts, and filled animal burrows between the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, and a depth of 1 m or a lithic or paralithic or petroferric contact, whichever is shallower; and

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm

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or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; and

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Ustorthents are like Typic Ustorthents except for *a*.

Lithic Ustorthents are like Typic Ustorthents except for *c*.

Vermic Ustorthents are like Typic Ustorthents except for *d*.

Vertic Ustorthents are like Typic Ustorthents except for *e*.

Xerorthents

Distinctions between Typic Xerorthents and other subgroups

Typic Xerorthents are the Xerorthents that

a. Are not saturated with water within 1.5 m of the surface at any time of year in most years;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick, that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have a lithic contact within 50 cm of the soil surface; and

d. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 cm and 75 cm below the soil surface.

Aquic Xerorthents are like Typic Xerorthents except for *a*.

Aquic Durorthidic Xerorthents are like Typic Xerorthents except for *a* and *b*.

Durorthidic Xerorthents are like Typic Xerorthents except for *b*.

Dystric Xerorthents are like Typic Xerorthents except for *d*.

Lithic Xerorthents are like Typic Xerorthents except for *c* or for *c* and *d*.

PSAMMENTS

Key to great groups

JCA. Psamments that have a cryic or pergelic soil temperature regime.

Cryopsamments, p. 121

JCB. Other Psamments that have a torric moisture regime.

Torripsamments, p. 122

JCC. Other Psamments that have a sand fraction that is 95 percent or more quartz, zircon, tourmaline, rutile, and other normally insoluble crystalline minerals that do not weather to liberate iron or aluminum.

Quartzipsamments, p. 121

JCD. Other Psamments that have a udic moisture regime and mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5°C or more.

Udipsamments, p. 123

JCE. Other Psamments that have a udic moisture regime.

Tropopsamments, p. 123

JCF. Other Psamments that have a xeric moisture regime.

Xeropsamments, p. 124

JCG. Other Psamments.

Ustipsamments, p. 124

Cryopsamments

Distinctions between Typic Cryopsamments and other subgroups

Typic Cryopsamments are the Cryopsamments that

a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;

b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface;

c. Have a mean annual soil temperature that is higher than 0°C;

d. Do not have a lithic contact within 50 cm of the soil surface; and

e. Do not have an albic horizon that is 5 cm or more thick and underlain by a horizon that has a color value one unit or more darker and that meets all requirements of a spodic horizon except the index of accumulation.

Alfic Cryopsamments are like Typic Cryopsamments except for *a*.

Aquic Cryopsamments are like Typic Cryopsamments except for *b*.

Lithic Cryopsamments are like Typic Cryopsamments except for *d* or for *c* and *d*.

Pergelic Cryopsamments are like Typic Cryopsamments except for *c*, with or without *b*.

Spodic Cryopsamments are like Typic Cryopsamments except for *e*.

Quartzipsamments

Distinctions between Typic Quartzipsamments and other subgroups

Typic Quartzipsamments are the Quartzipsamments that

a. Do not have mottles above a depth of 1 m that have chroma of 2 or less or, if the color is due to uncoated sand grains, do not have the water table within 1 m of the soil surface for as many as 60 days, cumulative, in most years;

b. Do not have an albic horizon[9] at the surface or immediately under an A1 or an Ap horizon that is underlain by another horizon that has a color value more than one unit darker or chroma of 6 or more;

ENT

c. Do not have a lithic contact within 50 cm of the soil surface;
d. Have a clay fraction that has a higher CEC than that of the clay of an oxic horizon or >25 percent of the surfaces of sand grains are uncoated;
e. Have <5 percent plinthite in all horizons above a depth of 1 m; and
f. Have a udic moisture regime.

Aquic Quartzipsamments are like Typic Quartzipsamments except for *a*.

Haplaquodic Quartzipsamments are like Typic Quartzipsamments except for *a* and *b*. They have a ground-water table that is within 1 m of the soil surface for 6 months or more in most years or are artificially drained, and they have a difference of 5° C or more between the mean summer and mean winter soil temperatures at a depth of 50 cm.

Lithic Quartzipsamments are like Typic Quartzipsamments except for *c*.

Orthoxic Quartzipsamments are like Typic Quartzipsamments except for *d*, with or without *e*, and they have enough clay to coat at least 75 percent of the surfaces of the sand grains.

Spodic Quartzipsamments are like Typic Quartzipsamments except for *b*.

Tropaquodic Quartzipsamments are like Typic Quartzipsamments except for *a* and *b*, and they have a difference of <5° C between the mean winter and mean summer soil temperatures at a depth of 50 cm.

Ustoxic Quartzipsamments are like Typic Quartzipsamments except for *d* and *f*, with or without *e*. They have an ustic moisture regime and have enough clay to coat at least 75 percent of the surfaces of the sand grains.

Torripsamments

Distinctions between Typic Torripsamments and other subgroups

Typic Torripsamments are the Torripsamments that
a. Do not have a lithic contact within 50 cm of the soil surface;
b. Do not have a horizon within 1 m of the surface that is >15 cm thick and either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist; and
c. Are dry in all parts of the moisture control section three-fourths or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher.

Durorthidic Xeric Torripsamments are like Typic Torripsamments except for *b* and *c*, and they have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on xeric.

Lithic Torripsamments are like Typic Torripsamments except for *a* or for *a* and *c*.

Ustic Torripsamments are like Typic Torripsamments except for *c*, and they have a torric moisture regime that borders on an ustic regime.

Xeric Torripsamments are like Typic Torripsamments except for *c*, and they have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on an xeric regime.

Tropopsamments

Distinctions between Typic Tropopsamments and other subgroups

Typic Tropopsamments are the Psamments that

a. Do not have a lithic contact within 50 cm of the soil surface; and

b. Do not have mottles above a depth of 1 m that have chroma of 2 or less, or if the color is due to uncoated sand grains, have a ground-water table within 1 m of the soil surface for less than 60 cumulative days in most years.

Aquic Tropopsamments are like Typic Tropopsamments except for *b*.

Lithic Tropopsamments are like Typic Tropopsamments except for *a*.

Udipsamments

Distinctions between Typic Udipsamments and other subgroups

Typic Udipsamments are the Udipsamments that

a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;[10]

b. Do not have mottles that have chroma of 2 or less above a depth of 1 m;

c. Do not have a lithic contact within a depth of 50 cm;

d. Do not have an albic horizon that is thick enough to be preserved after the soil has been mixed to a depth of 18 cm and is underlain by a horizon that has a color value one unit or more darker and that meets all requirements for a spodic horizon except the index of accumulation; and

e. Do not have a surface horizon between 25 and 50 cm thick that meets all requirements for a plaggen epipedon except thickness.

Alfic Udipsamments are like Typic Udipsamments except for *a* and have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella or have a frigid temperature regime.

Aquic Udipsamments are like Typic Udipsamments except for *b* with or without *a* or *d* or both.

Lithic Udipsamments are like Typic Udipsamments except for *c*.

Plaggeptic Udipsamments are like Typic Udipsamments except for *e*.

Spodic Udipsamments are like Typic Udipsamments except for *d*.

Ultic Udipsamments are like Typic Udipsamments except for *a*, have base saturation of <35 percent in some horizon <1.25 m below the uppermost lamella, and have a mesic or warmer temperature regime.

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Ustipsamments

Distinctions between Typic Ustipsamments and other subgroups

Typic Ustipsamments are the Ustipsamments that
a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;[11]
b. Do not have distinct or prominent mottles above a depth of 1 m and are not saturated with water within 1 m of the surface during any time of year in most years; and
c. Do not have a lithic contact within 50 cm of the surface.

Alfic Ustipsamments are like Typic Ustipsamments except for *a,* have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella, and have a color value, moist, of 4 or more within 25 cm of the surface.

Aquic Ustipsamments are like Typic Ustipsamments except for *b.*

Lithic Ustipsamments are like Typic Ustipsamments except for *c.*

Xeropsamments

Distinctions between Typic Xeropsamments and other subgroups

Typic Xeropsamments are the Xeropsamments that
a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;[12]
b. Do not have distinct or prominent mottles above a depth of 1 m and are not saturated with water within 1 m of the surface during any time of year in most years;
c. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
d. Do not have a lithic contact within 50 cm of the soil surface; and
e. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 cm and 75 cm below the soil surface.

Alfic Xeropsamments are like Typic Xeropsamments except for *a* and have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella.

Aquic Xeropsamments are like Typic Xeropsamments except for *b.*

Aquic Durorthidic Xeropsamments are like Typic Xeropsamments except for *b* and *c.*

Dystric Xeropsamments are like Typic Xeropsamments except for *e.*

Lithic Xeropsamments are like Typic Xeropsamments except for *d* or for *d* and *e.*

[1] Lamellae that are <1 cm thick or that are too few to meet the requirements for an argillic horizon are permitted to have texture of sandy loam. See the definition of an argillic horizon (ch. 1).

[2] Soils that otherwise could be Aquents are grouped with Aquepts if there is permafrost.

[3] The carbon should be of Holocene age. It is not the intent to include fossil carbon from transported fragments of bedrock or from buried Pleistocene deposits. The mean residence time of the carbon should be <11,000 years B.P.

[4] If the hue of the matrix is 7.5YR or redder and if peds are present, ped exteriors have dominant chroma, moist, of 1 or less, and ped interiors have mottles that have chroma, moist, of 2 or less; if peds are absent, the chroma, moist, is 1 or less immediately below any surface horizon that has value, moist, less than 3.5.

[5] See footnote 4 above.

[6] See footnote 3 above.

[7] The weighted average particle-size class between a depth of 25 cm and either a depth of 1 m or a lithic or paralithic contact, whichever is shallower.

[8] The clay content cannot be estimated with precision in lamallae that are very thin. The lamellae in soils of alfic subgroups generally are about 0.5 to 1 cm thick, but their total thickness is less than the 15 cm required for an argillic horizon.

[9] The albic horizon must be thick enough to be preserved after the soil to a depth of 18 cm is mixed.

[10] See footnote 8 above.

[11] See footnote 8 above.

[12] See footnote 8 above.

Chapter 8
Histosols

Key to suborders

AA. Histosols that

1. Are never saturated with water for more than a few days following heavy rains and

   a. Have a lithic or paralithic contact <1 m from the surface or have fragmental materials in which the interstices are filled or partly filled with organic materials in half or more of each pedon, or both; and

   b. Less than three-fourths of the thickness of organic materials consists of *Sphagnum* fibers.

Folists, p. 132

AB. Other Histosols that

1. Are dominantly[1] fibric in the subsurface tier if that tier is wholly organic except for a thin mineral layer or layers, or the organic parts of the surface and subsurface tiers are dominantly fibric if a continuous mineral layer 40 cm or more thick begins within the depth limit of the subsurface tier; or
2. Have a surface mantle that has three-fourths or more of its volume consisting of fibers derived from *Sphagnum* and that rests on a lithic or paralithic contact, fragmental materials, or mineral soil, or on frozen[2] materials within the limits in depth of the surface or subsurface tier; and
3. Do not have a sulfuric horizon whose upper boundary is within 50 cm of the surface and do not have sulfidic materials within 1 m of the surface.

Fibrists, p. 127

AC. Other Histosols that

1. Are dominantly hemic in the subsurface tier if that tier is wholly organic except for a thin mineral layer or layers; or are dominantly hemic in the organic part of the surface and subsurface tiers if a continuous mineral layer 40 cm or more thick begins within the depth limits of the subsurface tier; or
2. Have a sulfuric horizon whose upper boundary is within 50 cm of the surface or have sulfidic materials within 1 m of the surface.

Hemists, p. 133

AD. Other Histosols.

Saprists, p. 136

FIBRISTS

Key to great groups

ABA. Fibrists that have a surface mantle that is three-fourths or more fibric *Sphagnum* spp. and that either is 90 cm or more thick, or extends 10 cm or more below permafrost, or rests on a lithic or paralithic contact, fragmental materials, or mineral soil materials.

Sphagnofibrists, p. 130

ABB. Other Fibrists that are frozen in most years in some layer within the control section about 2 months after the summer solstice or that are never frozen in most years below a depth of 5 cm but have a mean annual soil temperature that is lower than 8°C.

Cryofibrists, p. 129

ABC. Other Fibrists that have a mean annual soil temperature lower than 8°C.

Borofibrists, p. 128

ABD. Other Fibrists that have a difference of <5°C between mean summer and mean winter soil temperatures at a depth of 30 cm.

Tropofibrists, p. 131

IST

ABE. Other Fibrists that do not have a horizon 2 cm or more thick that is half or more humilluvic materials.

Medifibrists, p. 129

ABF. Other Fibrists.

Luvifibrists, p. 129

Borofibrists

Distinctions between Typic Borofibrists and other subgroups

Typic Borofibrists are the Borofibrists that

a. Have

(1) Less than 25 cm of the subsurface and bottom tiers occupied by hemic materials; and

(2) Less than 12.5 cm of the subsurface and bottom tiers occupied by sapric materials;

b. Have less than three-fourths of the fibers (by volume) derived from *Sphagnum* in the surface tier or more of the control section;

c. Do not have limnic layer(s) within the control section 5 cm or more thick;

d. Do not have a lithic contact within the control section;

e. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin continuous mineral layers in the control section below the surface tier;

f. Do not have a mineral layer 30 cm or more thick whose upper boundary is below the surface tier in the control section; and

g. Do not have a layer of water within the control section beneath the surface tier.

Fluvaquentic Borofibrists are like Typic Borofibrists except for *e* with or without *a*.

Hemic Borofibrists are like Typic Borofibrists except for *a(1)*.

Hemic Terric Borofibrists are like Typic Borofibrists except for *a(1)* and *f*, with or without *c* or *e*, or both.

Hydric Borofibrists are like Typic Borofibrists except for *g*.

Limnic Borofibrists are like Typic Borofibrists except for *c*, with or without *a* or *e*, or both.

Lithic Borofibrists are like Typic Borofibrists except for *d*, with or without all or any of *a*, *b*, *c*, *e*, or *f*.

Sapric Borofibrists are like Typic Borofibrists except for *a(2)*.

Sapric Terric Borofibrists are like Typic Borofibrists except for *a(2)* and *f*, with or without *c* or *e*, or both.

Sphagnic Borofibrists are like Typic Borofibrists except for *b*.

Sphagnic Terric Borofibrists are like Typic Borofibrists except for *b* and *f*, with or without *c* or *e*, or both.

Terric Borofibrists are like Typic Borofibrists except for *f*, with or without *c* or *e*, or both.

Cryofibrists

Distinctions between Typic Cryofibrists and other subgroups

Typic Cryofibrists are the Cryofibrists that

a. Have less than three-fourths of their fiber volume derived from *Sphagnum* spp. in the surface tier or more of the control section;

b. Have a mean annual soil temperature higher than 0° C;

c. Do not have a lithic contact within the control section;

d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

e. Do not have a mineral layer 30 cm or more thick whose upper boundary is below the surface tier in the control section; and

f. Have organic materials that are continuous laterally throughout each pedon in at least the surface tier.

Fluvaquentic Cryofibrists are like Typic Cryofibrists except for *d.*

Lithic Cryofibrists are like Typic Cryofibrists except for *c,* with or without *a* or both *a* and *b.*

Pergelic Cryofibrists are like Typic Cryofibrists except for *b,* with or without any or all or *a,d,* or *e.*

Sphagnic Cryofibrists are like Typic Cryofibrists except for *a.*

Terric Cryofibrists are like Typic Cryofibrists except for *e* or for *d* and *e.*

IST

Luvifibrists

Luvifibrists are not known to occur in the United States, but the great group is provided tentatively for use in other countries if needed. These soils are the Fibrists that have a horizon within the control section that is 2 cm or more thick and is half or more humilluvic materials. Because these soils cannot be studied in the United States, a precise definition is not attempted here. It should be noted, however, that the soils normally are acid and that they have been cultivated for a long time.

Medifibrists

Distinctions between Typic Medifibrists and other subgroups

Typic Medifibrists are the Medifibrists that

a. Have

(1) Less than 25 cm of the subsurface and bottom tiers occupied by hemic materials; and

(2) Less than 12.5 cm of the subsurface and bottom tiers occupied by sapric materials;

b. Have less than three-fourths of the fiber volume in the surface tier or more of the control section derived from *Sphagnum;*

c. Do not have limnic layer(s) that are 5 cm or more thick within the control section;
d. Do not have a lithic contact within the control section;
e. Do not have a mineral layer betwen 5 cm and 30 cm thick within organic materials or do not have two or more thin continuous mineral layers in the control section below the surface tier;
f. Do not have a mineral layer 30 cm or more thick whose upper boundary in the control section is below the surface tier; and
g. Do not have a layer of water within the control section beneath the surface tier.

Fluvaquentic Medifibrists are like Typic Medifibrists except for *e*, with or without *a*.

Hemic Medifibrists are like Typic Medifibrists except for *a(1)*.

Hemic Terric Medifibrists are like Typic Medifibrists except for *a(1)* and *f*, with or without *c* or *e*, or both.

Hydric Medifibrists are like Typic Medifibrists except for *g*.

Limnic Medifibrists are like Typic Medifibrists except for *c*, with or without *e* or *a*, or both.

Lithic Medifibrists are like Typic Medifibrists except for *d*, with or without all or any of *a*, *b*, *c*, *e*, or *f*.

Sapric Medifibrists are like Typic Medifibrists except for *a(2)*.

Sapric Terric Medifibrists are like Typic Medifibrists except for *a(2)*, and *f*, with or without *c* or *e*, or both.

Sphagnic Medifibrists are like Typic Medifibrists except for *b*.

Sphagnic Terric Medifibrists are like Typic Medifibrists except for *b* and *f*, with or without *c* or *e*, or both.

Terric Medifibrists are like Typic Medifibrists except for *f*, with or without *c* or *e*, or both.

Sphagnofibrists

Distinctions between Typic Sphagnofibrists and other subgroups

Typic Sphagnofibrists are the Sphagnofibrists that
a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin continuous mineral layers in the control section below the surface tier;
b. Have
(1) Less than 25 cm of the subsurface and bottom tiers occupied by hemic materials; and
(2) Less than 12.5 cm of the subsurface and bottom tiers occupied by sapric materials;
c. Do not have a layer of water within the contol section beneath the surface tier;
d. Do not have limnic layer(s) that are 5 cm or more thick within the control section.
e. Do not have a lithic contact within the control section;
f. Do not have a mineral layer 30 cm or more thick that has

its upper boundary in the control section below the surface tier;
g. Are never frozen within the control section about 2 months after the summer solstice or are never frozen below a depth of 5 cm in most years;
h. Have a mean annual soil temperature higher than 0° C.

Cryic Sphagnofibrists are like Typic Sphagnofibrists except for *g* and have a mean annual soil tempertaure lower than 8° C but higher than 0° C.

Fluvaquentic Sphagnofibrists are like Typic Sphagnofibrists except for *a,* with or without *b.*

Hemic Sphagnofibrists are like Typic Sphagnofibrists except for *b(1).*

Hydric Sphagnofibrists are like Typic Sphagnofibrists except for *c.*

Limnic Sphagnofibrists are like Typic Sphagnofibrists except for *d,* with or without *a* or *b,* or both.

Lithic Sphagnofibrists are like Typic Sphagnofibrists except for *e,* with or without all or any of *a, b, d,f,* or *h.*

Pergelic Sphagofibrists are like Typic Sphagnofibrists except for *h* and *g,* with or without all or any of *a, b, d, e,* or *f.*

Sapric Sphagnofibrists are like Typic Sphagnofibrists except for *b(2).*

Terric Sphagnofibrists are like Typic Sphagnofibrists except for *f,* with or without *a* or *d,* or both.

Tropofibrists

IST

Distinctions between Typic Tropofibrists and other subgroups

Typic Tropofibrists are the Tropofibrists that
a. Have
(1) Less than 25 cm of the thickness of the subsurface and bottom tiers occupied by hemic materials, and
(2) Less than 12.5 cm of the thickness of the subsurface and bottom tiers occupied by sapric materials;
b. Have less than three-fourths of their fibers, by volume, derived from *Sphagnum* in the surface tier or in more of the control section;
c. Do not have limnic layer(s) that are 5 cm or more thick within the control section;
d. Do not have a lithic contact within the control section;
e. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;
f. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier; and
g. Do not have a layer of water within the control section beneath the surface tier.

Fluvaquentic Tropofibrists are like Typic Tropofibrists except for *e,* with or without *a.*

Hemic Tropofibrists are like Typic Tropofibrists except for *a (1).*

Hemic Terric Tropofibrists are like Typic Tropofibrists except for *a(1)* and *f*, with or without *c* or *e*, or both.

Hydric Tropofibrists are like Typic Tropofibrists except for *g*.

Limnic Tropofibrists are like Typic Tropofibrists except for *c*, with or without *a* or *e*, or both.

Lithic Tropofibrists are like Typic Tropofibrists except for *d*, with or without all or any of *a*, *b*, *c*, *e*, or *f*.

Sapric Tropofibrists are like Typic Tropofibrists except for *a(2)*.

Sapric Terric Tropofibrists are like Typic Tropofibrists except for *a(2) and f*, with or without *c* or *e*, or both.

Terric Tropofibrists are like Typic Tropofibrists except for *f*, with or without *c* or *e*, or both.

FOLISTS

Key to great groups

AAA. Folists that have a cryic or colder temperature regime.

Cryofolists, p. 132

AAB. Other Folists that have an isomesic or warmer temperature regime.

Tropofolists, p. 132

AAC. Other Folists that have a frigid temperature regime.

Borofolists, p. 132

Borofolists

Distinctions between Typic Borofolists and other subgroups

Typic Borofolists are the Borofolists that

a. Have fragmental materials with interstices filled with organic materials in half or more of each pedon; and

b. Do not have a lithic contact within 1 m of the surface.

Lithic Borofolists are like the Typic Borofolists except for *b* or for *a* and *b*.

Cryofolists

Distinctions between Typic Cryofolists and other subgroups

Typic Cryofolists are the Cryofolists that

a. Have fragmental materials in which the interstices are filled or partly filled with organic materials in half or more of each pedon; and

b. Do not have a lithic contact within 1 m of the surface.

Lithic Cryofolists are like Typic Cryofolists except for *b* or for *a* and *b*.

Tropofolists

Distinctions between Typic Tropofolists and other subgroups

Typic Tropofolists are the Tropofolists that

a. Have fragmental materials in which the interstices are

filled or partly filled with organic materials in half or more of each pedon; and

b. Do not have a lithic contact within 1 m of the surface.

Lithic Tropofolists are like Typic Tropofolists except for *b* or for *a* and *b*.

HEMISTS

Key to great groups

ACA. Hemists that have a sulfuric horizon that has its upper boundary within 50 cm of the surface.

Sulfohemists, p. 135

ACB. Other Hemists that have sulfidic materials within 1 m of the surface.

Sulfihemists, p. 135

ACC. Other Hemists that have a horizon 2 cm or more thick in which half or more of the volume is humilluvic materials.

Luvihemists, p. 134

ACD. Hemists that are frozen in some layers within the control section about 2 months after the summmer solstice in most years or that are never frozen below a depth of 5 cm in most years but have a mean annual soil temperature lower than 8° C.

Cryohemists, p. 134

ACE. Other Hemists that have a mean annual soil temperature lower than 8° C.

Borohemists, p. 133

ACF. Other Hemists that have a difference of <5° C between mean summer and mean winter soil temperatures at a depth of 30 cm.

Tropohemists, p. 136

ACG. Other Hemists.

Medihemists, p. 135

Borohemists

Distinctions between Typic Borohemists and other subgroups

Typic Borohemists are the Borohemists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 25 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of sapric materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Borohemists are like Typic Borohemists except for *b(1)*.

Fibric Terric Borohemists are like Typic Borohemists

except for *b(1)* and *c*, with or without *a* or *e*, or both.

Fluvaquentic Borohemists are like Typic Borohemists except for *a*, with or without *b*.

Hydric Borohemists are like Typic Borohemists except for *d*.

Limnic Borohemists are like Typic Borohemists except for *e*, with or without *a* or *b*, or both.

Lithic Borohemists are like Typic Borohemists except for *f*, with or without all or any of *a*, *b*, *c*, or *e*.

Sapric Borohemists are like Typic Borohemists except for *b(2)*.

Sapric Terric Borohemists are like Typic Borohemists except for *b(2)* and *c*, with or without *a* or *e*, or both.

Terric Borohemists are like Typic Borohemists except for *c*, with or without all or any of *a*, *d*, or *e*.

Cryohemists

Distinctions between Typic Cryohemists and other subgroups

Typic Cryohemists are the Cryohemists that

a. Do not have a lithic contact within the control section;

b. Have a mean annual soil temperature higher than 0° C;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

e. Have organic materials that are continuous laterally throughout each pedon in at least the surface tier.

Fluvaquentic Cryohemists are like Typic Cryohemists except for *d*.

Lithic Cryohemists are like Typic Cryohemists except for *a* or for *a* and *b*.

Pergelic Cryohemists are like Typic Cryohemists except for *b*, with or without *d*.

Terric Cryohemists are like Typic Cryohemists except for *c*, with or without *d*.

Luvihemists

Luvihemists are not known to occur in the United States but the great group is provided tentatively for use in other countries if needed. They are the Hemists that have a horizon that is 2 cm or more thick within the control section, and half or more of the volume of that horizon is humilluvic materials. Because these soils cannot be studied in the United States, a precise definition is not attempted here. It should be noted, however, that they are normally acid and that they have been cultivated for a long time.

Medihemists

Distinctions between Typic Medihemists and other subgroups

Typic Medihemists are the Medihemists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 25 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of sapric materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) that are 5 cm or more thick within the control section;and

f. Do not have a lithic contact within the control section.

Fibric Medihemists are like Typic Medihemists except for *b(1).*

Fibric Terric Medihemists are like Typic Medihemists except for *b(1)* and *c,* with or without *a* or *e,* or both.

Fluvaquentic Medihemists are like Typic Medihemists except for *a,* with or without *b.*

Hydric Medihemists are like Typic Medihemists except for *d.*

Limnic Medihemists are like Typic Medihemists except for *e,* with or without *a* or *b,* or both.

Lithic Medihemists are like Typic Medihemists except for *f,* with or without all or any of *a, b, c,* or *e.*

Sapric Medihemists are like Typic Medihemists except for *b(2).*

Sapric Terric Medihemists are like Typic Medihemists except for *b(2)* and *c,* with or without *a* or *e,* or both.

Terric Medihemists are like Typic Medihemists except for *c,* with or without *a* or *e,* or both.

Sulfihemists

Distinctions between Typic Sulfihemists and other subgroups

Typic Sulfihemists are the Sulfihemists that

a. Do not have a mineral layer 30 cm or more thick that has its lower boundary in the control section below the surface tier.

Terric Sulfihemists are like Typic Sulfihemists except for *a.*

Sulfohemists

Definition

Sulfohemists are the hemists that have a sulfuric horizon

IST

whose upper boundary is within 50 cm of the surface.

The Sulfohemists are rare in the world and, provisionally, all Sulfohemists are considered to be Typic Sulfohemists.

Tropohemists

Distinctions between Typic Tropohemists and other subgroups

Typic Tropohemists are the Tropohemists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 25 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of sapric materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have a limnic layer(s) that are 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Tropohemists are like Typic Tropohemists except for *b(1)*.

Fibric Terric Tropohemists are like Typic Tropohemists except for *b(1)* and *c*, with or without *a*.

Fluvaquentic Tropohemists are like Typic Tropohemists except for *a*, with or without *b*.

Hydric Tropohemists are like Typic Tropohemists except for *d*.

Limnic Tropohemists are like Typic Tropohemists except for *e*, with or without *a* or *b*, or both.

Lithic Tropohemists are like Typic Tropohemists except for *f*, with or without all or any of *a*, *b*, *c*, or *e*.

Sapric Tropohemists are like Typic Tropohemists except for *b(2)*.

Sapric Terric Tropohemists are like Typic Tropohemists except for *b(2)* and *c*, with or without *a* or *e*, or both.

Terric Tropohemists are like Typic Tropohemists except for *c*, with or without *a* or *e*, or both.

SAPRISTS

Key to great groups

ADA. Saprists that are frozen in some layer within the control section about 2 months after the summer solstice or that are never frozen below a depth of 5 cm but have a mean annual soil temperature lower than 8°C.

Cryosaprists, p. 138

ADB. Other Saprists that have a mean annual soil temperature lower than 8°C.

Borosaprists, p. 137

ADC. Other Saprists that have <5°C difference between summer and mean winter soil temperatures at a depth of 30 cm.

Troposaprists, p. 139

ADD. Other Saprists that do not have a horizon of humilluvic materials 2 cm or more thick.

Medisaprists, p. 138

In addition to the great groups listed in the key, a great group of Vermisaprists may be needed, particularly for soils that have been drained for a long time, but a definition cannot be suggested at present.

Borosaprists

Distinctions between Typic Borosaprists and other subgroups

Typic Borosaprists are the Borosaprists that

a. Do not have a mineral layer between 5 and 30 cm thick with organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) that are 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Borosaprists are like Typic Borosaprists except for *b(1)*.

Fibric Terric Borosaprists are like Typic Borosaprists except for *b(1)* and *c*, with or without *a* or *e*, or both.

Fluvaquentic Borosaprists are like Typic Borosaprists except for *a*, with or without *b*.

Hemic Borosaprists are like Typic Borosaprists except for *b(2)*.

Hemic Terric Borosaprists are like Typic Borosaprists except for *b(2)* and *c*, with or without *a* or *e*, or both.

Limnic Borosaprists are like Typic Borosaprists except for *e*, with or without *a* or *b*, or both.

Lithic Borosaprists are like Typic Borosaprists except for *f*, with or without all or any of *a*, *b*, *c*, or *e*.

Terric Borosaprists are like Typic Borosaprists except for *c*, with or without *a* or *e*, or both.

IST

Cryosaprists

Distinctions between Typic Cryosaprists and other subgroups

Typic Cryosaprists are the Cryosaprists that

a. Do not have a lithic contact within the control section;
b. Have a mean annual soil temperature higher than 0° C;
c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;
d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier; and
e. Have organic materials that are continuous laterally in at least the surface tier throughout each pedon.

Fluvaquentic Cryosaprists are like Typic Cryosaprists except for *d.*

Lithic Cryosaprists are like Typic Cryosaprists except for *a* or for *a* and *b.*

Pergelic Cryosaprists are like Typic Cryosaprists except for *b* or for *b* and *d.*

Terric Cryosaprists are like Typic Cryosaprists except for *c.*

Medisaprists

Distinctions between Typic Medisaprists and other subgroups

Typic Medisaprists are the Medisaprists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;
b. Have
- (1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and
- (2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;
d. Do not have a layer of water within the control section beneath the surface tier;
e. Do not have limnic layer(s) that are 5 cm or more thick within the control section; and
f. Do not have a lithic contact within the control section.

Fibric Medisaprists are like Typic Medisaprists except for *b(1).*

Fibric Terric Medisaprists are like Typic Medisaprists except for *b(1)* and *c,* with or without *a* or *e,* or both.

Fluvaquentic Medisaprists are like Typic Medisaprists except for *a,* with or without *b.*

Hemic Medisaprists are like Typic Medisaprists except for *b(2).*

Hemic Terric Medisaprists are like Typic Medisaprists

except for *b(2)* and *c,* with or without *a* or *e,* or both.

Limnic Medisaprists are like Typic Medisaprists except for *e,* with or without *a* or *b,* or both.

Lithic Medisaprists are like Typic Medisaprists except for *f,* with or without all or any of *a, b, c,* or *e.*

Terric Medisaprists are like Typic Medisaprists except for *c,* with or without *a* or *e,* or both.

Troposaprists

Distinctions between Typic Troposaprists and other subgroups

Typic Troposaprists are the Troposaprists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) that are 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Troposaprists are like Typic Troposaprists except for *b(1).*

Fibric Terric Troposaprists are like Typic Troposaprists except for *b(1)* and *c,* with or without *a* or *e,* or both.

Fluvaquentic Troposaprists are like Typic Troposaprists except for *a,* with or without *b.*

Hemic Troposaprists are like Typic Troposaprists except for *b(2).*

Hemic Terric Troposaprists are like Typic Troposaprists except for *b(2)* and *c,* with or without *a* or *e,* or both.

Limnic Troposaprists are like Typic Troposaprists except for *e,* with or without *a* or *b,* or both.

Lithic Troposaprists are like Typic Troposaprists except for *f,* with or without all or any of *a, b, c,* or *e.*

Terric Troposaprists are like Typic Troposaprists except for *c,* with or without *a* or *e,* or both.

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[1] Dominant, in this context, means the most abundant. If only two kinds of organic materials are present, the fibric materials occupy half or more of the volume. If there are both hemic and sapric materials as well as fibric, the fibric materials may occupy less than half of the volume but have more volume than either the hemic or sapric materials.

[2] Frozen 2 months after the summer solstice.

Chapter 9
Inceptisols

Key to suborders

IA. Inceptisols that

1. Have an aquic moisture regime or are artificially drained and have one or more of the following:

a. A histic epipedon;

b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;

c. An umbric or mollic epipedon that is underlain immediately or at a depth <50 cm below the soil surface by a horizon that has dominant colors, moist, on ped faces, or in the matrix if peds are absent, as follows:

(1) If there is mottling, chroma is 2 or less;[1]

(2) If there is no mottling, chroma is 1 or less;

d. An ochric epipedon that is underlain at a depth <50 cm below the mineral soil surface by a cambic horizon or a fragipan either or both which has dominant color, moist, on ped faces, or in the matrix if peds are absent as follows:

(1) If there is mottling, chroma is 2 or less;[1]

(2) If there is no mottling, chroma is 1 or less;

2. Or have an SAR ≥13 (or sodium saturation that is 15 percent or more) in half or more of the soil to a depth of 50 cm below the soil to a depth of 50 cm that decreases with depth below 50 cm and ground water within 1 m of the surface at some time of the year.

Aquepts, p. 145

IB. Other Inceptisols that have to a depth of 35 cm or more, or to a lithic or paralithic contact if one is shallower than 35 cm, one or both of the following:

1. Bulk density (at 1/3-bar water retention) of the fine-earth fraction that is <0.85 g per cubic centimeter and an exchange complex that is dominated by amorphous materials; or

2. Sixty percent or more of the soil (by weight) is vitric[2] volcanic ash, cinders or other pyroclastic materials.

Andepts, p. 141

IC. Other Inceptisols that have a plaggen epipedon.

Plaggepts, p. 159

ID. Other Inceptisols that have an isomesic or warmer iso temperature regime.

Tropepts, p. 159

IE. Other Inceptisols that have an ochric epipedon; or that have an umbric or mollic epipedon that is <25 cm thick and have also a mesic or warmer soil temperature regime.

Ochrepts, p. 151

IF. Other Inceptisols.

Umbrepts, p. 164

ANDEPTS

Key to great groups

IBA. Andepts that have a cryic or pergelic temperature regime.

Cryandepts, p. 142

IBB. Other Andepts that have a duripan that has its upper boundary within 1 m of the soil surface.

Durandepts, p. 142

IBC. Other Andepts that have clays that dehydrate irreversibly into aggregates of sand and gravel size.

Hydrandepts, p. 144

EPT

IBD. Other Andepts that have a placic horizon within 1 m of the soil surface in half or more of each pedon.

Placandepts, p. 144

IBE. Other Andepts that are not thixotropic and in which the weighted average 15-bar water retention[3] of the fine-earth fraction is <20 percent for all horizons between a depth of 25 cm and 1 m or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m.

Vitrandepts, p. 144

IBF. Other Andepts that have a base saturation (by NH_4OAc) of 50 percent or more in some subhorizon between a depth of 25 and 75 cm.

Eutrandepts, p. 143

IBG. Other Andepts.

Dystrandepts, p. 143

Cryandepts

Distinctions between Typic Cryandepts and other subgroups

The subgroups of Cryandepts have not been fully developed because the soils are too few and those in the United States are too inaccessible. To date they have had only preliminary study.

Typic Cryandepts are Cryandepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface;

b. Are not thixotropic in half or more of the thickness of all horizons between depths of 25 cm and 1 m, and the weighted average 15-bar water retention[4] is <20 percent between depths of 25 cm and 1 m, or between 25 cm and a lithic or paralithic contact if there is one between 50 cm and 1 m;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have an epipedon that has the color and thickness of a mollic epipedon or have a horizon that meets the color and thickness requirements of a mollic epipedon and has its upper boundary within 50 cm of the soil surface;

e. Have a mean annual soil temperature higher than 0° C;

f. Do not have a placic horizon;

g. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

Dystric Cryandepts are like Typic Cryandepts except for *b,* with or without *d,* and base saturation (by NH_4OAc) is <50 percent in all subhorizons between 25 and 75 cm.

Dystric Lithic Cryandepts are like Typic Cryandepts except for *b* and *c,* and base saturation (by NH_4OAc) is <50 percent in all subhorizons between 25 and 75 cm.

Entic Cryandepts are like Typic Cryandepts except for *d.*

Lithic Cryandepts are like Typic Cryandepts except for *c* or for *c* and *d.*

Durandepts

Proposed distinctions between Typic Durandepts and other subgroups

Typic Durandepts are the Durandepts that

a. Have an ustic moisture regime;

b. Have an epipedon that meets the color and thickness requirements of a mollic epipedon;
c. Have a duripan that is continuous throughout each pedon or, if fractured, the average lateral dimensions of the fragments are $\geq$10 cm.

Entic Durandepts are like Typic Durandepts except for *c.*

Xeric Durandepts are like Typic Durandepts except for *a,* and they have a xeric moisture regime.

Dystrandepts

Distinctions between Typic Dystrandepts and other subgroups

Typic Dystrandepts are the Dystrandepts that
a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface;
b. Have an epipedon that is 25 cm or more thick and meets the color requirements of a mollic epipedon;
c. Are not thixotropic in any horizon between depths of 25 cm and 1 m;
d. Do not have a lithic contact within 50 cm of the soil surface;
e. Have cation-exchange capacity[5] of >30 meq per 100 g soil (by NH_4OAc) in all subhorizons above a lithic contact or a depth of 1 m, whichever is shallower, or have >10 percent weatherable minerals in the 20- to 200-micron fraction.

Aquic Dystrandepts are like Typic Dystrandepts except for *a.*

Entic Dystrandepts are like Typic Dystrandepts except for *b.*

Hydric Dystrandepts are like Typic Dystrandepts except for *c,* with or without *b.*

Hydric Lithic Dystrandepts are like Typic Dystrandepts except for *c* and *d,* with or without *b.*

Lithic Dystrandepts are like Typic Dystrandepts except for *d,* with or without *b.*

Oxic Dystrandepts are like Typic Dystrandepts except for *e,* with or without *b,* and they have <10 percent weatherable minerals in the 20-to 200-micron fraction.

Eutrandepts

Distinctions between Typic Eutrandepts and other subgroups

Typic Eutrandepts are the Eutrandepts that
a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface;
b. Have an epipedon, 25 cm or more thick, that meets the color requirements of a mollic epipedon;
c. Do not have a lithic contact within 50 cm of the soil surface;
d. Do not have a subhorizon within 1.5 m of the surface that contains soft, powdery secondary lime;
e. Have an ustic moisture regime;

f. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more (by volume) durinodes or has >50 percent (by volume) fragments of a duripan in which the average horizontal repeat distance between vertical cracks is <10 cm.

Duric Eutrandepts are like Typic Eutrandepts except for *f*.

Entic Eutrandepts are like Typic Eutrandepts except for *b* or for *b* and *d*.

Lithic Eutrandepts are like Typic Eutrandepts except for *c*.

Udic Eutrandepts are like Typic Eutrandepts except for *e*, and they have a udic moisture regime.

Ustollic Eutrandepts are like Typic Eutrandepts except for *d*.

Xeric Eutrandepts are like Typic Eutrandepts except for *e*, and they have a xeric moisture regime.

Hydrandepts

Distinction between Typic and Lithic Hydrandepts

Typic Hydrandepts are the Hydrandepts that

a. Do not have a lithic contact within 50 cm of the soil surface.

Lithic Hydrandepts are like Typic Hydrandepts except for *a*.

Placandepts

These are the Andepts that have a placic horizon. Like the Hydrandepts, they are mostly in very humid climates that do not have a dry season. The placic horizon is a barrier to water movement and root development. Water commonly saturates much of the soil above the pan for variable periods. This great group is represented by a very few soil series in the United States. The soils have been reported in other countries. These soils were called Hydrol Humic Latosols in the 1938 classification as modified in 1955.

Subgroups have not been developed because the soils are too poorly represented in the United States. It is thought that soils of the typic subgroup should have, within 1 m of the surface, a placic horizon that is continuous through each pedon.

Vitrandepts

Distinctions between Typic Vitrandepts and other subgroups

Typic Vitrandepts are the Vitrandepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water in most years at some period when its temperature is >5° C or if the soil is artificially drained;

b. Do not have a lithic contact within 50 cm of the soil surface; and

c. Have an ochric epipedon.

Aquic Vitrandepts are like Typic Vitrandepts except for *a.*

Lithic Vitrandepts are like Typic Vitrandepts except for *b.*

Lithic Mollic Vitrandepts are like Typic Vitrandepts except for *b* and *c,* and they have a mollic epipedon.

Lithic Umbric Vitrandepts are like Typic Vitrandepts except for *b* and *c,* and they have an umbric epipedon.

Mollic Vitrandepts are like Typic Vitrandepts except for *c,* and they have a mollic epipedon.

Plaggic Vitrandepts are like Typic Vitrandepts except for *c,* and they have either a plaggen epipedon or an epipedon that meets all requirements for a plaggen epipedon except thickness and is 30 cm or more thick.

Umbric Vitrandepts are like Typic Vitrandepts except for *c,* and they have an umbric epipedon.

AQUEPTS

Key to great groups

IAA. Aquepts that have a sulfuric horizon whose upper boundary is within 50 cm of the mineral soil surface.

Sulfaquepts, p. 150

IAB. Other Aquepts that have a placic horizon within 1 m of the mineral soil surface in half or more of each pedon.

Placaquepts, p. 150

IAC. Other Aquepts that have an SAR$\geq$13 (or have sodium saturation that is $\geq$15 percent) in half or more of the upper 50 cm of soil that decreases with depth below 50 cm.

Halaquepts, p. 147

IAD. Other Aquepts that have a fragipan.

Fragiaquepts, p. 147

IAE. Other Aquepts that have a cryic or pergelic soil temperature regime.

Cryaquepts, p. 146

IAF. Other Aquepts that have plinthite that forms a continuous phase or constitutes more than half the matrix within some subhorizon in the upper 1.25 m of the soil.

Plinthaquepts, p. 150

IAG. Other Aquepts that have, to a depth of 35 cm or more or to a lithic or paralithic contact if one is shallower than 35 cm, one or both of the following:

1. Bulk density (at 1/3-bar water retention) of the fine-earth fraction that is <0.85 g per cubic centimeter and an exchange complex that is dominated by amorphous materials; or

2. Sixty percent or more of the soil (by weight) is vitric[6] volcanic ash, cinders, or other pyroclastic materials.

Andaquepts, p. 146

IAH. Other Aquepts that have a difference of <5°C between the mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Tropaquepts, p. 150

IAI. Other Aquepts that have an umbric, a mollic, or a histic epipedon.

Humaquepts, p. 149

IAJ. Other Aquepts.

Haplaquepts, p. 148

EPT

Andaquepts

Distinctions between Typic Andaquepts and other subgroups

Typic Andaquepts are the Andaquepts that

a. Have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and if the hue is 2.5Y or redder and the value, moist, is 5 or more, the chroma, moist, is 2 or less;

(2) If mottled and if the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) Whether mottled or not, the chroma, moist, is 1 or less; and

b. Have an umbric epipedon.

Aeric Andaquepts are like Typic Andaquepts except for *a.*

Aeric Mollic Andaquepts are like Typic Andaquepts except for *a* and *b,* and they have a mollic epipedon.

Haplic Andaquepts are like Typic Andaquepts except for *b,* and they have an ochric epipedon.

Mollic Andaquepts are like Typic Andaquepts except for *b,* and they have a mollic epipedon.

Cryaquepts

Distinctions between Typic Cryaquepts and other defined subgroups

It seems probable that a number of subgroups besides those here defined will be needed when the soils that occur in striped or polygonal patterns have been studied in more detail.

Typic Cryaquepts are the Cryaquepts that

a. Have chroma of 2 or less in 60 percent or more of the mass of all horizons between depths of 15 and 50 cm;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3- bar tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Do not have a histic epipedon;

d. Do not have an umbric or a mollic epipedon;

e. Do not have a lithic contact within 50 cm of the soil surface;

f. Have a mean annual soil temperature that is higher than 0° C.

Aeric Cryaquepts are like Typic Cryaquepts except for *a.*

Aeric Humic Cryaquepts are like Typic Cryaquepts except for *a* and *d,* and they have an umbric epipedon.

Andic Cryaquepts are like Typic Cryaquepts except for *b* or for *b* and *d.*

Histic Cryaquepts are like Typic Cryaquepts except for *c* or for *c* and *d*.

Histic Lithic Cryaquepts are like Typic Cryaquepts except for *c* and *e*, with or without *f*.

Histic Pergelic Cryaquepts are like Typic Cryaquepts except for *c* and *f*, and the histic epipedon is continuous in each pedon.

Humic Cryaquepts are like Typic Cryaquepts except for *d*, and they have an umbric epipedon.

Humic Pergelic Cryaquepts are like Typic Cryaquepts except for *d* and *f*, with or without *a*, and they have an umbric epipedon.

Pergelic Cryaquepts are like Typic Cryaquepts except for *f* or for *f* and *a*.

Pergelic Ruptic-Histic Cryaquepts are like Typic Cryaquepts except for *c* and *f*, and the histic epipedon is not continuous in each pedon.

Fragiaquepts

Distinctions between Typic Fragiaquepts and other subgroups

Typic Fragiaquepts are the Fragiaquepts that

a. Do not have a histic, mollic, or umbric epipedon; and

b. Have, in 60 percent or more of the matrix of all subhorizons between the plow layer or, if there is no plow layer, a depth of 15 cm and a depth of 75 cm or more, moist colors as follows:

(1) If there is mottling, chroma of 2 or less;

(2) If there is no mottling, chroma of 1 or less.

Aeric Fragiaquepts are like Typic Fragiaquepts except for *b*.

Humic Fragiaquepts are like Typic Fragiaquepts except for *a*.

EPT

Halaquepts

Distinctions between Typic Halaquepts and other subgroups

Typic Halaquepts are the Halaquepts that

a. Have chroma of 2 or less and a hue of 5Y or redder in 60 percent or more of the matrix in all subhorizons between depths of 15 and 75 cm;

b. Have an ochric epipedon;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aeric Halaquepts are like Typic Halaquepts except for *a*.

Mollic Halaquepts are like Typic Halaquepts except for *b*.

Vertic Halaquepts are like Typic Halaquepts except for *c*.

Haplaquepts

Distinctions between Typic Haplaquepts and other subgroups

Typic Haplaquepts are the Haplaquepts that

a. Have, in 60 percent or more of the matrix in all subhorizons between the A1 or Ap horizon and a depth of 75 cm, one or more of the following:

(1) If mottled and the mean annual soil temperature is lower than 15° C, moist chroma of 2 or less;

(2) If mottled and the mean annual soil temperature is 15° C or higher;

(a) If the hue is 2.5Y or redder[7] and the value, moist, is more than 5, the chroma, moist, is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) The chroma, moist, is 1 or less and mottles may or may not be present;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk denisty (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an Ap horizon that has a color value, moist, of 4 or more or has a value, dry, of 6 or more when crushed and smoothed, or have an A1 horizon that is <15 cm thick if its color value, moist, is lower than 3.5;

d. Have an n value of <0.9 between depths of 50 and 80 cm and <0.7 in all layers between 20 and 50 cm;

e. Do not have a lithic contact within 50 cm of the soil surface;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic

or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

g. Do not have either of the following:

(1) Jarosite mottles and a pH between 3.5 and 4.0 (1:1 water, air dried slowly in shade) in some subhorizon within 50 cm of the soil surface, or

(2) Jarosite mottles and a pH <4.0 (1:1 water, air dried slowly in shade) in some subhorizon between depths of 50 and 150 cm.

Aeric Haplaqupets are like Typic Haplaquepts except for *a* or for *a* and *c*.

Humic Haplaquepts are like Typic Haplaquepts except for *c*, and the base saturation (by NH_4OAc) is <50 percent in some horizon and does not increase with depth to a value of 50 percent or more.

Lithic Haplaquepts are like Typic Haplaquepts except for *e* or for *a* and *e*.

Mollic Haplaquepts are like Typic Haplaquepts except for *c*, and the base saturation (by NH_4OAc) is 50 percent or more throughout or increases with depth to a value of 50 percent or more.

Sulfic Haplaquepts are like Typic Haplaquepts except for *g*, with or without all or any of *a*, *c*, *d*, or *f*.

Vertic Haplaquepts are like Typic Haplaquepts except for *f*, with or without *a* or *c*, or both.

Humaquepts

Distinctions between Typic Humaquepts and other subgroups

Typic Humaquepts are the Humaquepts that

a. Have chroma of 2 or less, moist, and hue of 5Y or redder in 60 percent or more of the matrix in all subhorizons between depths of 15 and 75 cm;

b. Have mottles or have iron-manganese concretions within a depth 30 cm below the base of the epipedon if the chroma within that depth is 1 or more, the hue is redder than 5Y, and the value, moist, is 5 or more;

c. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Have an epipedon that is <60 cm thick;

e. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface;

f. Do not have a histic epipedon whose upper boundary is at or near the soil surface; and

g. Have an *n* value of <0.9 between depths of 50 and 80 cm

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and 0.7 or less in all layers between depths of 20 and 50 cm.

Cumulic Humaquepts are like Typic Humaquepts except for *d* and *e*.

Fluvaquentic Humaquepts are like Typic Humaquepts except for *e*.

Histic Humaquepts are like Typic Humaquepts except for *f*, with or without all or any of *a*, *b*, or *e*.

Placaquepts

Distinctions between Typic Placaquepts and other subgroups

Typic Placaquepts are the Placaquepts that

a. Do not have a histic epipedon; and

b. Have a continuous placic horizon within 1 m of the soil surface throughout each pedon.

Histic Placaquepts are like Typic Placaquepts except for *a*.

Plinthaquepts

These are mainly Aquepts of intertropical regions. They have plinthite that forms a continous phase or occupies more than half the matrix of some subhorizon deeper than 30 cm but within 1.25 m of the soil surface. These are soils in which the ground-water level fluctuates appreciably during the year. Water is at or near the surface during the rainy season but drops during a dry season. Most of these soils are in relatively recent alluvium, probably of late-Pleistocene or Holocene age. Weatherable minerals are present in appreciable amounts. These soils are not known to occur in the United States, but the great group is provided because the soils are thought to be extensive in parts of the Amazon basin.

Sulfaquepts

Definition

Sulfaquepts are the Aquepts that have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Subgroups of Sulfaquepts have not been fully developed. It is thought that few subgroups are needed because the sulfuric horizon is so highly toxic. The Typic Sulfaquepts have a sulfuric horizon within 50 cm of the soil surface. A histic epipedon is permitted but is not required.

Tropaquepts

Distinctions between Typic Tropaquepts and other subgroups

Typic Tropaquepts are the Tropaquepts that

a. Have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and if the hue is 2.5Y or redder and the

value, moist, is >5, the chroma, moist, is 2 or less; if the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(2) If mottled and if the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) The chroma, moist, is 1 or less whether mottled or not;

b. Do not have a histic epipedon that has its upper boundary at or near the surface;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Do not have the following combination of characteristics:

(1) Cracks at some time in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

e. Have <5 percent (by volume) of plinthite in all subhorizons within 1.5 m of the soil surface;

f. Do not have either of the following:

(1) Jarosite mottles and a pH between 3.5 and 4.0 (1:1 water, air dried slowly in shade) in some subhorizon within 50 cm of the soil surface; or

(2) Jarosite mottles and a pH <4.0 (1:1 water, air dried slowly in shade) in some subhorizon between depths of 50 and 150 cm.

Aeric Tropaquepts are like Typic Tropaquepts except for *a*.

Histic Tropaquepts are like Typic Tropaquepts except for *b*.

Lithic Tropaquepts are like Typic Tropaquepts except for *c*.

Plinthic Tropaquepts are like Typic Tropaquepts except for *e* or for *a* and *e*.

Sulfic Tropaquepts are like Typic Tropaquepts except for *f*, with or without all or any of *a*, *b*, or *d*.

Vertic Tropaquepts are like Typic Tropaquepts except for *d*, with or without *a*.

OCHREPTS

Key to great groups

IEA. Ochrepts that have a fragipan.

Fragiochrepts, p. 156

IEB. Other Ochrepts that have a duripan whose upper boundary is within 1 m of the soil surface.

Durochrepts, p. 152

IEC. Other Ochrepts that have a cryic or pergelic temperature regime.

Cryochrepts, p. 152

IED. Other Ochrepts that have an ustic moisture regime.

Ustochrepts, p. 156

IEE. Other Ochrepts that have a xeric moisture regime.

Xerochrepts, p. 158

IEF. Other Ochrepts that have one or both of the following:

1. Carbonates in the cambic horizon or in the C horizon but within the soil; or

2. Base saturation (by NH_4OAc) that is 60 percent or more in some subhorizon between depths of 25 and 75 cm below the soil surface.

Eutrochrepts, p. 154

IEG. Other Ochrepts.

Dystrochrepts, p. 153

Cryochrepts

Distinctions between Typic Cryochrepts and other subgroups

Typic Cryochrepts are the Cryochrepts that

a. Have a mean annual soil temperature higher than 0° C;

b. Do not have a lithic contact within 50 cm of the soil surface;

c. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some period when its temperature is $\geq$5° C or the soil has artificial drainage.

d. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of $>$1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

e. Have base saturation (by NH_4OAc) that is 60 percent or more in some subhorizon within 75 cm of the surface; and

f. Do not have lamellae within 75 cm of the soil surface that meet all requirements for an argillic horizon except thickness.

Alfic Cryochrepts are like Typic Cryochrepts except for *f.*

Andic Cryochrepts are like Typic Cryochrepts except for *d* or for *d* and *e.*

Aquic Cryochrepts are like Typic Cryochrepts except for *c* or *c* and *e.*

Dystric Cryochrepts are like Typic Cryochrepts except for *e.*

Lithic Cryochrepts are like Typic Cryochrepts except for *b,* with or without *a* or *d,* or both.

Pergelic Cryochrepts are like Typic Cryochrepts except for *a* or for *a* and *c.*

Durochrepts

Distinctions between Typic Durochrepts and other subgroups

Typic Durochrepts are the Durochrepts that

a. Have a platy or massive indurated duripan;
b. Do not have distinct or prominent mottles within the upper 30 cm;
c. Have a xeric moisture regime; and
d. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 and 75 cm below the soil surface.

Dystric Entic Durochrepts are like Typic Durochrepts except for *a* and *d*.

Entic Durochrepts are like Typic Durochrepts except for *a*.

Dystrochrepts

Distinctions between Typic Dystrochrepts and other subgroups

Typic Dystrochrepts are the Dystrochrepts that
a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
b. Do not have mottles that have chroma of 2 or less within 60 cm of the soil surface if the mottled horizon is saturated with water at a time when its temperature is 5° C or higher, or the soil has artificial drainage.
c. Have a content of organic carbon [8] that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the surface; or have slopes >25 percent;
d. Do not have a lithic contact within 50 cm of the soil surface;
e. Do not have an argillic horizon in any part of the pedon; and
f. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more, crushed and smoothed, or the upper soil to a depth of 18 cm, after mixing, has these colors.

Andic Dystrochrepts are like Typic Dystrochrepts except for *a*.

Aquic Dystrochrepts are like Typic Dystrochrepts except for *b*.

Fluvaquentic Dystrochrepts are like Typic Dystrochrepts except for *b* and *c*.

Fluventic Dystrochrepts are like Typic Dystrochrepts except for *c*.

Fluventic Umbric Dystrochrepts are like Typic Dystrochrepts except for *c* and *f*.

Lithic Dystrochrepts are like Typic Dystrochrepts except for *d*.

Lithic Ruptic-Alfic Dystrochrepts are like Typic Dystrochrepts except for *d* and *e*, they have an argillic horizon in

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less than half of each pedon and their base saturation (by sum of cations) in the subhorizon just above the lithic contact that is ≥35 percent.

Lithic Ruptic-Ultic Dystrochrepts are like Typic Dystrochrepts except for *d* and *e*, and they have an argillic horizon in less than half of each pedon and have base saturation (by sum of cations) in the subhorizon just above the lithic contact that is <35 percent.

Ruptic-Alfic Dystrochrepts are like Typic Dystrochrepts except for *e* and they have an argillic horizon in less than half of each pedon and base saturation (by sum of cations) that is 35 percent or more at a depth 1.25 m below the upper boundary of the argillic horizon or just above a lithic or paralithic contact if one is present at a shallower depth.

Ruptic-Ultic Dystrochrepts are like Typic Dystrochrepts except for *e*, and they have an argillic horizon in less than half of each pedon and have base saturation (by sum of cations) that is <35 percent at a depth 1.25 m below the top of the argillic horizon.

Umbric Dystrochrepts are like Typic Dystrochrepts except for *f*.

Eutrochrepts

Distinctions between Typic Eutrochrepts and other subgroups

Typic Eutrochrepts are the Eutrochrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 60 cm of the soil surface if the mottled horizon is saturated with water at some period when its temperature is ≥5° C or if the soil has artificial drainage;

c. Have texture of very fine sand or finer within 50 cm of the soil surface;

d. Have carbonates within a depth of 1 m in some part of each pedon;

e. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

f. Do not have a lithic contact within 50 cm of the soil surface in any part of the pedon;

g. Do not have an argillic horizon in any part of the pedon;

h. Have an ochric epipedon;

i. Do not have either of the following combinations of characteristics:

(1) All three of the following characteristics:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend to the soil surface or to the base of an Ap horizon,

(b) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both of the following characteristics:

(a) A lithic or paralithic contact or altered rock that retains its rock structure within 50 cm of the soil surface, and

(b) Horizons that total 25 cm or more in thickness and have 35 percent or more clay that has montmorillonitic mineralogy; and

j. Have <40 percent carbonates, including the coarse fragments up to 75 mm in diameter, in and below the cambic horizon but above a lithic or paralithic contact and above a depth of 1 m.

Andic Dystric Eutrochrepts are like Typic Eutrochrepts except for *a* and *d*.

Aquic Eutrochrepts are like Typic Eutrochrepts except for *b*.

Aquic Dystric Eutrochrepts are like Typic Eutrochrepts except for *b* and *d*.

Arenic Eutrochrepts are like Typic Eutrochrepts except for *c*.

Dystric Eutrochrepts are like Typic Eutrochrepts except for *d*.

Dystric Fluventic Eutrochrepts are like Typic Eutrochrepts except for *d* and *e*.

Fluvaquentic Eutrochrepts are like Typic Eutrochrepts except for *b* and *e*, with or without *d*.

Fluventic Eutrochrepts are like Typic Eutrochrepts except for *e*.

Lithic Eutrochrepts are like Typic Eutrochrepts except for *f* or for *d* and *f*.

Lithic Ruptic-Alfic Eutrochrepts are like Typic Eutrochrepts except for *f* and *g*, and they have an argillic horizon in some part but in less than half of each pedon.

Rendollic Eutrochrepts are like Typic Eutrochrepts except for *j*.

Ruptic-Alfic Eutrochrepts are like Typic Eutrochrepts except for *g* and have an argillic horizon in some part but in less than half of each pedon.

Vertic Eutrochrepts are like Typic Eutrochrepts except for *i(1)*, with or without *e* or *b*, or both.

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Fragiochrepts

Distinctions between Typic Fragiochrepts and other subgroups

Typic Fragiochrepts are the Fragiochrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have distinct or prominent mottles in the upper 30 cm of the soil; and

c. Have an ochric epipedon.

Andic Fragiochrepts are like Typic Fragiochrepts except for *a.*

Aquic Fragiochrepts are like Typic Fragiochrepts except for *b.*

Ustochrepts

Distinctions between Typic Ustochrepts and other subgroups

Typic Ustochrepts are the Ustochrepts that

a. Have a content of organic carbon[9] that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reached a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

b. Do not have a lithic contact within 50 cm of the surface;

c. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and that are at least 30 cm long in some part and that extend upward to the soil surface or the base of an Ap horizon,

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both of the following:

(a) Have within 50 cm of the soil surface a lithic or paralithic contact or altered rock that retains its rock structure, and

(b) Have horizons totaling 25 cm or more in thickness that have 35 percent or more clay that has montmorillonitic mineralogy;

d. Do not have mottles that have chroma of 2 or less within

75 cm of the soil surface if the mottled horizon is saturated with water at some period when its temperature is 5°C or more or if the soil has artificial drainage;

e. Have a calcic horizon or soft, powdery secondary lime within a depth 70 cm below the soil surface if the weighted average particle-size class is loamy from a depth of 25 cm to 1 m or between 25 cm and a lithic or paralithic contact that is shallower than 1 m, within a depth of 60 cm if the particle-size class is clayey, and within 1 m if it is sandy;

f. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic cemtimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

g. When neither irrigated nor fallowed to store moisture:

(1) If the soil temperature regime is mesic or thermic, are dry less than sixth-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during the period when the soil temperature, at a depth 50 cm below the surface, exceeds 5° C;

(2) If the soil temperature regime is hyperthermic or isomesic or warmer, are moist in some or all parts of the soil moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth 50 cm below the soil surface is higher than 8° C.

Andic Ustochrepts are like Typic Ustochrepts except for *f* or for *f* and *e*.

Aridic Ustochrepts are like Typic Ustochrepts except for *g*.

Fluventic Ustochrepts are like Typic Ustochrepts except for *a*.

Lithic Ustochrepts are like Typic Ustochrepts except for *b*, with or without *e* or *g*, or both.

Lithic Vertic Ustochrepts are like Typic Ustochrepts except for *c(2)*, with or without *g*, and they have a lithic contact within 50 cm of the soil surface.

Paralithic Vertic Ustochrepts are like Typic Ustochrepts except for *b* and *c(2)*, with or without *g*, and they have within 50 cm of the soil surface a paralithic contact or altered rock that retains its rock structure.

Udic Ustochrepts are like Typic Ustochrepts except for *e*.

Vertic Ustochrepts are like Typic Ustochrepts except for *c(1)*, with or without *a* or *d*, or both.

Xerochrepts

Distinctions between Typic Xerochrepts and other subgroups

Typic Xerochrepts are the Xerochrepts that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface;

b. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 and 75 cm below the soil surface;

c. Have a content of organic carbon that decreases regularly with depth, and unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensiblity of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both the following:

(a) Have within 50 cm of the soil surface a lithic or parlithic contact or altered rock that retains its rock structure; and

(b) Have horizons totaling 25 cm or more in thickness that have 35 percent or more clay that has montmorillonitic mineralogy or a COLE ≥0.05;

f. Do not have a calcic horizon or soft powdery lime within a depth of 1.5 m if the weighted average particle-size class from depths of 25 cm to 1 m is sandy or to a lithic or paralithic contact if one is shallower than 1 m, or within a depth of 1.1 m if the weighted average particle-size class is loamy, or within a depth of 90 cm if it is clayey;

g. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is a much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andic Xerochrepts are like Typic Xerochrepts except for *g* or for *b* and *g*.

Aquic Xerochrepts are like Typic Xerochrepts except for *a*.

Aquic Dystric Xerochrepts are like Typic Xerochrepts except for *a* and *b*.

Calcixerollic Xerochrepts are like Typic Xerochrepts except for *f*.

Dystric Xerochrepts are like Typic Xerochrepts except for *b*.

Dystric Fluventic Xerochrepts are like Typic Xerochrepts except for *b* and *c*.

Dystric Lithic Xerochrepts are like Typic Xerochrepts except for *b* and *d*.

Fluventic Xerochrepts are like Typic Xerochrepts except for *c*.

Lithic Xerochrepts are like Typic Xerochrepts except for *d*.

Lithic Ruptic-Xerorthentic Xerochrepts are like Typic Xerochrepts except for *d*, and have an intermittent cambic horizon.

Lithic Vertic Xerochrepts are like Typic Xerochrepts except for *d* and *e(2)*, and they have a lithic contact.

Paralithic Vertic Xerochrepts are like Typic Xerochrepts except for *e(2)*. and they have a paralithic contact or altered rock that retains its rock structure.

Ruptic-Lithic Xerochrepts are like Typic Xerochrepts except for *d* and have a lithic contact in some part but less than half of each pedon.

Vertic Xerochrepts are like Typic Xerochrepts except for *e(1)*, with or without *a* or *c*, or both.

PLAGGEPTS

Plaggepts are the soils that have a plaggen epipedon that is composed of crystalline rather than pyroclastic materials. This suborder includes all freely drained soils that have a plaggen epipedon except a few Andepts.

TROPEPTS

Key to great groups

IDA. Tropepts that have base saturation of <50 percent (by NH_4OAc) in some subhorizon between depths of 25 cm and 1 m and have 12 kg or more organic carbon, exclusive of surface litter, per square meter in the soil to a depth of 1 m, or to a lithic, paralithic, or petroferric contact if one is shallower than 1 m, and do not have a sombric horizon.

Humitropepts, p. 162

IDB. Other Tropepts that have a sombric horizon.

Sombritropepts, p. 163

IDC. Other Tropepts that have an ustic moisture regime or have soft powdery lime within 1.5 m of the soil surface and have base saturation (by NH_4OAc) of 50 percent or more in all subhorizons between depths of 25 cm and 1 m, or between 25 cm and a lithic, paralithic or petroferric contact if one is shallower than 1 m.

Ustropepts, p. 163

IDD. Other Tropepts that have base saturation (by NH_4OAc) of 50

percent or more in all subhorizons between depths of 25 cm and 1 m, or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m.

Eutropepts, p. 161

IDE. Other Tropepts.

Dystropepts, p. 160

Dystropepts

Distinctions between Typic Dystropepts and other subgroups

Typic Dystropepts are the Dystropepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water at some time of year or the soil has artificial drainage.

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have a cambic horizon;

d. Have a content of organic carbon [10] that decreases regularly with depth and, unless a lithic or paralithic contact is present at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface, or have slopes >25 percent;

e. Do not have a lithic or a petroferric contact within 50 cm of the soil surface;

f. Have in all horizons above a lithic contact or above a depth of 1 m, whichever is shallower, a CEC (by NH_4OAc) of 24 or more meq per 100 g clay.[11]

g. Have a udic moisture regime; and

h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more if the soil moisture regime is udic, or 0.07 or more it if is ustic, in a horizon or horizons at least 50 cm thick, and a potential linear extensibility of 6 cm or more in the upper 1 m or 1.25 m, respectively, of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m or 1.25 m;

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Dystropepts are like Typic Dystropepts except for *a.*

Fluventic Dystropepts are like Typic Dystropepts except for *d.*

Lithic Dystropepts are like Typic Dystropepts except for *e* and have a lithic contact within a depth of 50 cm.

Oxic Dystropepts are like Typic Dystropepts except for *f*.

Ustic Dystropepts are like Typic Dystropepts except for *g*, and they have an ustic moisture regime.

Ustoxic Dystropepts are like Typic Dystropepts except for *f* and *g*, and they have an ustic moisture regime.

Vertic Dystropepts are like Typic Dystropepts except for *h*, with or without any or all of *a, c, d,* and *g*.

Eutropepts

Distinctions between Typic Eutropepts and other subgroups

Typic Eutropepts are the Eutropepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottle horizon is saturated with water at some time during the year or if there is artificial drainage.

c. Have a content of organic carbon[12] that decreases regularly with depth and, unless a lithic or a paralithic contact is present at a shallower depth, reaches a level of 0.2 percent organic carbon or less within 1.25 m of the soil surface; or have slopes >25 percent;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil, or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both the following:

(a) Have within 50 cm of the surface a lithic or

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paralithic contact or altered rock that retains its rock structure, and

(b) Have horizons totaling 25 cm or more in thickness that have 35 percent or more clay that has montmorillonitic mineralogy or that have a COLE $\geq$0.09; and

f. Have a cambic horizon.

Andic Eutropepts are like Typic Eutropepts except for *a*.

Aquic Eutropepts are like Typic Eutropepts except for *b*.

Fluvaquentic Eutropepts are like Typic Eutropepts except for *b* and *c*.

Fluventic Eutropepts are like Typic Eutropepts except for *c*.

Lithic Eutropepts are like Typic Eutropepts except for *d*.

Lithic Vertic Eutropepts are like Typic Eutropepts except for *d* and *e(2)*, with or without *f*.

Paralithic Vertic Eutropepts are like Typic Eutropepts except for *e(2)* and they have a paralithic contact or have altered rock that retains its rock structure.

Vertic Eutropepts are like Typic Eutropepts except for *e(1)*, with or without any or all of *b, c,* or *f*.

Humitropepts

Distinctions between Typic Humitropepts and other subgroups

Typic Humitropepts are the Humitropepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water at some time of year or if there is artificial drainage;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a CEC (by NH_4OAc) of 24 or more meq per 100 g clay.[13]

e. Have a content of organic carbon that decreases regularly with depth to the base of the cambic horizon, or have slopes >25 percent; and

f. Have a udic moisture regime.

Andic Humitropepts are like Typic Humitropepts except for *a* or for *a* and *e*.

Andic Ustic Humitropepts are like Typic Humitropepts except for *a* and *f*, with or without *e*, and they have an ustic moisture regime.

Fluventic Humitropepts are like Typic Humitropepts except for *e*.

Lithic Humitropepts are like Typic Humitropepts except for *c*.

Oxic Humitropepts are like Typic Humitropepts except for *d*.

Ustic Humitropepts are like Typic Humitropepts except for *f*, and they have an ustic moisture regime.

Ustoxic Humitropepts are like Typic Humitropepts except for *d* and *f*, and they have an ustic moisture regime.

Sombritropepts

These soils are the dark, humus-rich Tropepts of perhumid, cool, hilly or mountainous regions. They have a sombric horizon in or below a cambic horizon. Most of them have an umbric epipedon, a perudic soil moisture regime, and an isomesic temperature regime. They are not known to occur in the United States and their classification has not been developed.

Ustropepts

Distinctions between Typic Ustropepts and other subgroups

Typic Ustropepts are the Ustropepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water at some time of the year or if there is artificial drainage;

b. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent organic carbon or less within 1.25 m of the soil surface; or have slopes >25 percent;

c. Have a cambic horizon;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Have a CEC (by NH_4OAc) of 24 or more meq per 100 g clay[14] and

f. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both the following:

(a) Have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm of the surface; and

(b) Have horizons totaling 25 cm or more in

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thickness that have 35 percent or more clay that has montmorillonitic mineralogy or have a COLE ≥0.07.

Fluventic Ustropepts are like Typic Ustropepts except for *b,* with or without *c* or *e,* or both, and the organic-carbon content is ≥0.5 percent at a depth of 1.25 m below the soil surface if the CEC is <24 meq per 100 g clay in the major part of the cambic horizon or of the whole soil if there is no cambic horizon.

Lithic Ustropepts are like Typic Ustropepts except for *d.*

Lithic Vertic Ustropepts are like Typic Ustropepts except for *d* and *f(2),* with or without *c.*

Oxic Ustropepts are like Typic Ustropepts except for *e* or for *e* and *b,* and the organic-carbon content is <0.5 percent at a depth 1.25 m below the soil surface.

Paralithic Vertic Ustropepts are like Typic Ustropepts except for *f(2),* with or without *c,* and they have a paralithic contact or altered rock that retains its rock structure.

Vertic Ustropepts are like Typic Ustropepts except for *f(1),* with or without any or all of *a, b,* or *c.*

UMBREPTS

Key to great groups

IFA. Umbrepts that have a fragipan.

Fragiumbrepts, p. 165

IFB. Other Umbrepts that have a cryic or pergelic temperature regime.

Cryumbrepts, p. 164

IFC. Other Umbrepts that have a xeric moisture regime.

Xerumbrepts, p. 166

IFD. Other Umbrepts.

Haplumbrepts, p. 165

Cryumbrepts

Distinctions between Typic Cryumbrepts and other subgroups

Typic Cryumbrepts are the Cryumbrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Have a cambic horizon;

c. Do not have a lithic contact within 50 cm of the surface;

d. Have a mean annual soil temperature higher than 0° C;

e. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is ≥5° C or if there is artificial drainage; and

f. Have an umbric epipedon that is continuous in each pedon.

Andic Cryumbrepts are like Typic Cryumbrepts except for *a*.

Aquic Cryumbrepts are like Typic Cryumbrepts except for *e* or for *b* and *e*.

Entic Cryumbrepts are like Typic Cryumbrepts except for *b*.

Lithic Cryumbrepts are like Typic Cryumbrepts except for *c*, with or without *b* or *d*, or both.

Lithic Ruptic-Entic Cryumbrepts are like Typic Cryumbrepts except for *c* and *f*, with or without *b* or *d*, or both.

Pergelic Cryumbrepts are like Typic Cryumbrepts except for *d*, with or without *a* or *b* or both.

Ruptic-Lithic Cryumbrepts are like Typic Cryumbrepts except for *c*, with or without *b* or *d*, or both, and they have a lithic contact within 50 cm of the surface in only part of each pedon.

Fragiumbrepts

Distinctions between Typic Fragiumbrepts and other subgroups

The definitions that follow are incomplete because there are few of these soils in the United States.

Typic Fragiumbrepts are the Fragiumbrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimer or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum; and

b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface.

Andic Fragiumbrepts are like Typic Fragiumbrepts except for *a*.

Aquic Fragiumbrepts are like Typic Fragiumbrepts except for *b*.

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Haplumbrepts

Distinctions between Typic Haplumbrepts and other subgroups

Typic Haplumbrepts are the Haplumbrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is >5°C or if there is artificial drainage;

c. Have a cambic horizon;
d. Have a content of organic carbon[15] that decreases regularly with depth or have slopes >25 percent;
e. Do not have a lithic contact within 50 cm of the soil surface;
f. Have an umbric or a mollic epipedon that is <50 cm thick; and
g. Have texture finer than loamy fine sand within a depth of 50 cm.

Andic Haplumbrepts are like Typic Haplumbrepts except for *a* or for *a* and *f*.

Andaquic Haplumbrepts are like Typic Haplumbrepts except for *a* and *b* or *a, b,* and *f*.

Cumulic Haplumbrepts are like Typic Haplumbrepts except for *f* and *d,* with or without *b* or *c,* or both.

Entic Haplumbrepts are like Typic Haplumbrepts except for *c*.

Fluventic Haplumbrepts are like Typic Haplumbrepts except for *d*.

Lithic Haplumbrepts are like Typic Haplumbrepts except for *e* or for *c* and *e*.

Pachic Haplumbrepts are like Typic Haplumbrepts except for *f,* with or without *b* or *c,* or both.

Quartzipsammentic Haplumbrepts are like Typic Haplumbrepts except for *c* and *g,* with or without *f*. They have sandy texture to a depth of 1 m or more, and have in the sand fraction >95 percent quartz, zircon, tourmaline, rutile, and other normally unweatherable minerals.

Xerumbrepts

Distinctions between Typic Xerumbrepts and other subgroups

Typic Xerumbrepts are the Xerumbrepts that
a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is >5° C or if there is artificial drainage;
b. Have an umbric or mollic epipedon that is <50 cm thick;
c. Have a cambic horizon;
d. Have a content of organic carbon that decreases regularly with depth or have slopes >25 percent;
e. Do not have a lithic contact within 50 cm of the soil surface; and
f. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andic Xerumbrepts are like Typic Xerumbrepts except for *f*.

Entic Xerumbrepts are like Typic Xerumbrepts except for *c*.

Fluventic Xerumbrepts are like Typic Xerumbrepts except for *d*.

Lithic Xerumbrepts are like Typic Xerumbrepts except for *e*, with or without *c*.

Pachic Xerumbrepts are like Typic Xerumbrepts except for *b*, with or without *a* or *c*, or both.

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[1] If the hue is redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived.

[2] Included in the meaning of vitric materials in this definition are crystalline particles that are coated with glass and partially devitrified glass as well as glass.

[3] The amount of water retained at a tension of 15 bars may be reduced by drying these soils. Since 15-bar water retention is used as a measure of effective clay content, it would be unrealistic to use the extremely high value obtained on a field-moist Andept. That value reflects mostly the climatic history rather than a basic soil property. The value for 15-bar water retention that is referred to here, therefore, is that of a sample that has been dried at 40°C.

[4] See footnote 3 above.

[5] Andepts in a perhumid climate are never dry while they remain in place. They lose CEC if allowed to become air dry before the determination is made. The values used in these definitions are those determined on soil samples that have never been allowed to dry, but the values have been recalculated to an ovendry basis. The CEC of samples that have been air dried may be used if it has been determined that drying does not affect the CEC of that soil.

[6] See footnote 2 above.

[7] If the hue is 7.5YR or redder in the matrix and if peds are present, the ped exteriors should have dominant chroma, moist, of 1 or less and the ped interiors should have mottles that have chroma, moist, of 2 or less; if there are no peds, the chroma, moist, should be 1 or less immediately below any surface horizon that has a value, moist, less than 5.

[8] The carbon should be of Holocene age. It is not the intent to include fossil carbon from bedrock.

[9] See footnote 8 above.

[10] See footnote 8 above.

[11] Some cambic horizons that have properties that approach those of an oxic horizon do not disperse well. If the ratio of the percentage of water retained at tension of 15 bars to the percentage of measured clay is 0.6 or more, the percentage of clay is determined by the higher value of (1) the measured percentage of clay or (2) 2.5 times the percentage of water retained at tension of 15 bars.

[12] See footnote 8 above.

[13] See footnote 11 above.

[14] See footnote 11 above.

[15] See footnote 8 above.

Chapter 10
Mollisols

Key to suborders

GA. Mollisols that have all the following:

1. An albic horizon that lies immediately under the mollic epipedon or that separates horizons that together meet all the requirements of a mollic epipedon;

2. An argillic or a natric horizon; and

3. Chroma of 2 or less in the albic horizon or characteristics associated with wetness in the albic, argillic, or natric horizon, namely mottles or iron-manganese concretions larger than 2 mm or both.

Albolls, p. 170

GB. Other Mollisols that either have an aquic moisture regime or are artificially drained, and that have one or more of the following characteristics associated with wetness:

1. A histic epipedon overlying the mollic epipedon;

2. An SAR $\geq$13 (or sodium saturation of $\geq$15 percent) in the upper part of the mollic epipedon and decreasing SAR (or sodium saturation) with increasing depth below 50 cm;

3. One of the following combinations of colors, moist;

a. If the lower part of the mollic epipedon[1] has chroma of 1 or less, there are either

(1) Distinct or prominent mottles in the lower part of the mollic epipedon; or

(2) A color value, moist, of 4 or more immediately below the mollic epipedon, or within 75 cm of the surface if a calcic horizon intervenes, and one of the following:

(a) If the hue is 10YR or redder and there are mottles, chroma is less than 1.5 on ped surfaces or in the matrix; if there are no mottles, chroma is less than 1;

(b) If the hue is nearest 2.5Y and there are distinct or prominent mottles, chroma is 2 or less on ped surfaces or in the matrix; if there are no mottles, chroma is 1 or less;

(c) If the nearest hue is 5Y or yellower and there are distinct or prominent mottles, chroma is 3 or less on ped surfaces or in the matrix; if there are no mottles, chroma is 1 or less;

(d) The hue is bluer than 10Y or the color is neutral; or

(e) The color results from uncoated mineral grains; or

b. If the lower part of the mollic epipedon has chroma of more than 1 but not more than 2, there are either

(1) Distinct or prominent mottles in the lower mollic epipedon; or

(2) Base colors immediately below the mollic epipedon that have one or more of the following properties:

(a) Value of 4 and chroma of 2 and also some mottles that have value of 4 or more and chroma less than 2;

(b) Value of 5 or more and chroma of 2 or less and also mottles that have higher chroma; or

(c) Value of 4 and chroma <2; or

4. A calcic or petrocalcic horizon that has its upper boundary within 40 cm of the surface.

Aquolls, p. 171

GC. Other Mollisols that have all the following characteristics:

1. Have a mollic epipedon that is not more than 50 cm thick;

2. Do not have an argillic horizon;

3. Do not have a calcic horizon;

4. The soil materials in or immediately below any mollic epipedon,

including coarse fragments less than 7.5 cm in diameter, have a $CaCO_3$ equivalent of 40 percent or more; and
5. Have a udic moisture regime or a cryic temperature regime;

Rendolls, p. 182

GD. Other Mollisols that have a xeric moisture regime or an aridic moisture regime bordering on xeric but do not have a cryic temperature regime.

Xerolls, p. 194

GE. Other Mollisols that have a frigid, cryic, or pergelic temperature regime.

Borolls, p. 174

GF. Other Mollisols that have an ustic or an aridic moisture regime that borders on ustic or have, within 1.5 m of the soil surface or within 50 cm below the base of any cambic or argillic horizon, a gypsic horizon, or a calcic horizon, or a ca horizon that has concentrations of soft powdery lime in spheroidal forms or as coatings on peds, or disseminated[2] in clay-size particles.

Ustolls, p. 186

GG. Other Mollisols.

Udolls, p. 183

ALBOLLS

Key to great groups

GAA. Albolls that have a natric horizon.

Natralbolls, p. 170

GAB. Other Albolls.

Argialbolls, p. 170

Argialbolls

Distinctions between Typic Argialbolls and other subgroups

Typic Argialbolls are the Argialbolls that
a. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages)of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
b. Have an abrupt textural change from the albic to the argillic horizon;
c. When not irrigated, are not dry in all parts of the moisture control section for as long as 45 consecutive days during the 120 days following the summer solstice in more than 6 out of 10 years.

Argiaquic Argialbolls re like Typic Argialbolls except for *b.*

Argiaquic Xeric Argialbolls are like Typic Argialbolls except for *b* and *c.*

Xeric Argialbolls are like Typic Argialbolls except for *c.*

Natralbolls

Definition

Natralbolls are the Albolls that have a natric horizon.

AQUOLLS

Key to great groups

GBA. Aquolls that have a cryic or pergelic temperature regime.

Cryaquolls, p. 172

GBB. Other Aquolls that have a duripan that has its upper boundary within 1 m of the surface.

Duraquolls, p. 173

GBC. Other Aquolls that have a natric horizon.

Natraquolls, p. 174

GBD. Other Aquolls that have a calcic or gypsic horizon that has its upper boundary within 40 cm of the surface and do not have an argillic horizon unless it is a buried horizon.

Calciaquolls, p. 172

GBE. Other Aquolls that have an argillic horizon.

Argiaquolls, p. 171

GBF. Other Aquolls.

Haplaquolls, p. 173

Argiaquolls

Distinctions between Typic Argiaquolls and other subgroups

Typic Argiaquolls are the Argiaquolls that

a. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm from the upper boundary;

b. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the surface; and

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface of the soil or to the base of the Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the soil to a depth of 1 m or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Abruptic Argiaquolls are like Typic Argiaquolls except for *a*.

Arenic Argiaquolls are like Typic Argiaquolls except for *b* and have a sandy epipedon between 50 cm and 1 m thick.

Grossarenic Argiaquolls are like Typic Argiaquolls except for *b* and have a sandy epipedon >1 m thick.

Vertic Argiaquolls are like Typic Argiaquolls except for *c*.

Calciaquolls

Distinctions between Typic Calciaquolls and other subgroups

Typic Calciaquolls are the Calciaquolls that

a. Do not have color that has dominant chroma of 3 or more in the matrix or on the ped surfaces in any subhorizon within 75 cm of the surface and do have one or more of the following colors immediately below the mollic epipedon:

(1) If the nearest hue is 2.5Y or yellower and there are distinct or prominent mottles, the chroma, moist, is 2 or less; if there are no mottles, the chroma, moist, is 1 or less; or

(2) If the nearest hue is 10YR or redder and there are distinct or prominent mottles, the chroma is nearer to 1 than to 2; if there are no mottles, the chroma is 1 or less; and

b. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface.

Aeric Calciaquolls are like Typic Calciaquolls except for *a*.

Petrocalcic Calciaquolls are like Typic Calciaquolls except for *b*.

Cryaquolls

Distinctions between Typic Cryaquolls and other subgroups

Typic Cryaquolls are the Cryaquolls that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) in the fine-earth fraction of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have an argillic horizon;

c. Do not have a calcic horizon within or immediately underlying the mollic epipedon;

d. Have a mollic epipedon that is <50 cm thick;

e. Do not have a histic epipedon;

f. Have a mean annual soil temperature higher than 0° C; and

g. Do not have a buried Histosol that has its upper boundary within a depth of 1 m.

Argic Cryaquolls are like Typic Cryaquolls except for *b*, for *b* and *c*, or for *b*, *c*, and *d*.

Calcic Cryaquolls are like Typic Cryaquolls except for *c*.

Cumulic Cryaquolls are like Typic Cryaquolls except for *d*.

Histic Cryaquolls are like Typic Cryaquolls except for *e*.

Pergelic Cryaquolls are like Typic Cryaquolls except for *f* or for *e* and *f*.

Thapto-Histic Cryaquolls are like Typic Cryaquolls except for *g* or for *g* and *d*.

Duraquolls

Distinctions between Typic Duraquolls and other subgroups

Typic Duraquolls are the Duraquolls that
a. Do not have an argillic horizon; and
b. Do not have a natric horizon.

Argic Duraquolls are like Typic Duraquolls except for *a.*

Natric Duraquolls are like Typic Duraquolls except for *b.*

Haplaquolls

Distinctions between Typic Haplaquolls and other subgroups

Typic Haplaquolls are the Haplaquolls that
a. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have a buried Histosol that has its upper boundary within 1 m of the soil surface;
c. Have a mollic epipedon that is <60 cm thick;
d. Do not have a horizon 15 cm or more thick that is within 1 m of the surface and that contains at least 20 percent (by volume) of durinodes or is brittle and has firm consistence when moist;
e. Have a content of organic carbon that decreases regularly with increasing depth and reaches a level of 0.3 percent carbon or less in some subhorizon within 1.25 m of the soil surface, or the slope is >25 percent;
f. Do not have a histic epipedon;
g. Do not have a lithic contact within 50 cm of the surface; and
h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Andaqueptic Haplaquolls are like Typic Haplaquolls except for *a* or for *a* and *c.*

Cumulic Haplaquolls are like Typic Haplaquolls except for *c* or for *c* and *e*.

Duric Haplaquolls are like Typic Haplaquolls except for *d*.

Fluvaquentic Haplaquolls are like Typic Haplaquolls except for *e*.

Histic Haplaquolls are like Typic Haplaquolls except for *f*.

Lithic Haplaquolls are like Typic Haplaquolls except for *g*.

Vertic Haplaquolls are like Typic Haplaquolls except for *h*, with or without *c* or *e*, or both.

Natraquolls

Definition

Natraquolls are the Aquolls that

1. Have a natric horizon; and

2. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

BOROLLS

Key to great groups

GEA. Borolls that have an argillic horizon that has its upper boundary deeper than 60 cm below the mineral soil surface[3] and that have texture finer than loamy fine sand in all subhorizons above the argillic horizon.

Paleborolls, p. 181

GEB. Other Borolls that have a cryic or pergelic temperature regime.

Cryoborolls, p. 177

GEC. Other Borolls that have a natric horizon but do not have a cambic horizon that is above the natric horizon and separated from it by an albic horizon.

Natriborolls, p. 180

GED. Other Borolls that have an argillic horizon but do not have a cambic horizon that is above the argillic horizon and separated from it by an albic horizon.

Argiborolls, p. 175

GEE. Other Borolls that have a mollic epipedon that, below any Ap horizon, is 50 percent or more by volume wormholes, wormcasts, or filled animal burrows and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and the underlying horizon.

Vermiborolls, p. 181

GEF. Other Borolls that have a calcic or petrocalcic horizon whose upper boundary is within 1 m of the soil surface and that are calcareous in all parts of all horizons above the calcic or petrocalcic horizon, after the upper soil to a depth of 18 cm has been mixed, unless the texture is coarser than loamy very fine sand.

Calciborolls, p. 176

GEG. Other Borolls.

Haploborolls, p. 179

Argiborolls

Distinctions between Typic Argiborolls and other subgroups

Typic Argiborolls are the Argiborolls that

a. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm from the upper boundary;

b. Do not have either

(1) An albic horizon that lies immediately under the mollic epipedon; or

(2) Tonguing or interfingering of albic materials in the upper part of the argillic horizon, or skeletans of clean silt and sand covering more than half the ped faces in the upper 5 cm or more of the argillic horizon;

c. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3- bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Do not have mottles that have chroma of 2 or less within 1 m of the surface or, if undrained, are not continuously saturated with water for as long as 90 days within 1 m of the surface;

e. Do not have a lithic contact within 50 cm of the surface;

f. Have

(1) Either or both

(a) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm thick; or

(b) A moisture control section that is dry in some part less than six-tenths of the time that the soil temperature at a depth of 50 cm is above 5°C in most years; and

(2) A chroma (rubbed), moist, of 1.5 or more in the upper 18 cm of the mollic epipedon after mixing, or in any Ap horizon that is >18 cm thick and the soil is dry in all parts of the moisture control section at some time in most years;

g. Have a mollic epipedon that is <40 cm thick, or its texture is loamy fine sand or coarser; and

h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Abruptic Argiborolls are like Typic Argiborolls except for *a*, with or without *b(1)* or *h*, or both.

Abruptic Aridic Argiborolls are like Typic Argiborolls except for *a* and part of or all of *f(1)*, with or without *b(1)* or *h*, or both.

Abruptic Udic Argiborolls are like Typic Argiborolls except for *a* and *f(2)*, with or without *b(1)* or *h*, for *g*, with or without *d* or *f(1)*, or both.

Albic Argiborolls are like Typic Argiborolls except for *a*, *b(1)*, and *d*; or for *a* and *d*, with or without *f(2)*.

Aquic Argiborolls are like Typic Argiborolls except for *d*, with or without *f(2)*.

Aridic Argiborolls are like Typic Argiborolls except for *f(1)*.

Boralfic Argiborolls are like Typic Argiborolls except for *b(2)*.

Boralfic Udic Argiborolls are like Typic Argiborolls except for *b(2)* and *f(2)*.

Lithic Argiborolls are like Typic Argiborolls except for *e* or for *e* and *f(1)*.

Pachic Argiborolls are like Typic Argiborolls except for *g* with or without *d* or *f(1)* or both.

Pachic Udic Argiborolls are like Typic Argiborolls except for *f(2)* and *g*, with or without *d*.

Udic Argiborolls are like Typic Argiborolls except for *f(2)*.

Ustertic Argiborolls are like Typic Argiborolls except for *h* and *f(1)*, with or without *d* or *g*, or both.

Vertic Argiborolls are like Typic Argiborolls except for *h*, with or without *d* or *g*, or both.

Calciborolls

Distinctions between Typic Calciborolls and other subgroups

Typic Calciborolls are the Calciborolls that

a. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or if the mottled horizon is continuously saturated with water for as long as 90 days;

b. Have either or both

(1) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon after mixing, or in any Ap horizon that is >18 cm thick; or

(2) A moisture control section that is dry in some part less than six-tenths of the time in most years that the soil temperature at a depth of 50 cm is above 5° C;

c. Do not have a lithic contact within 50 cm of the surface; and

d. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface.

Aridic Calciborolls are like Typic Calciborolls except for *b*.

Lithic Calciborolls are like Typic Calciborolls except for

c or for *b(1)* and *c*.

Petrocalcic Calciborolls are like Typic Calciborolls except for *d*.

Cryoborolls

Distinctions between Typic Cryoborolls and other subgroups

Typic Cryoborolls are the Cryoborolls that

a. Do not have an argillic horizon;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Do not have distinct or prominent mottles that are due to segregation of iron or manganese within 1 m of the surface if artificially drained, or if undrained, are not continuously saturated with water within a depth of 1 m for as long as 90 days;

d. Do not have a calcic horizon within or immediately under the mollic epipedon unless the lower part of the mollic epipedon is also an argillic horizon;

e. Have a mollic epipedon that is <40 cm thick or that has texture of loamy fine sand or coarser;

f. Have a mollic epipedon that is continuous throughout each pedon;

g. Do not have a lithic contact within 50 cm of the surface;

h. Have a mean annual soil temperture higher than 0° C;

i. Do not have an albic horizon immediately below the mollic epipedon;

j. Do not have a duripan that has its upper boundary within 1 m of the soil surface;

k. Have a regular decrease in organic carbon content with increasing depth and unless a lithic or a paralithic contact is at some depth between 50 cm and 1.25 m below the soil surface, have an organic carbon content of 0.3 percent or less at a depth within 1.25 m of the surface or the slope is >25 percent; and

l. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) A potential linear extensibility of 6 cm or more in the upper 1 m of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total more than 50 cm in thickness.

Abruptic Cryoborolls are like Typic Cryoborolls except for *a* and *i* and have an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below the upper boundary of the argillic horizon.

Andeptic Cryoborolls are like Typic Cryoborolls except for *b* or for *b* and *e*.

Aquic Cryoborolls are like Typic Cryoborolls except for *c*.

Argiaquic Cryoborolls are like Typic Cryoborolls except for *a* and *c*.

Argic Cryoborolls are like Typic Cryoborolls except for *a*, and the argillic horizon is continuous throughout each pedon.

Argic Lithic Cryoborolls are like Typic Cryoborolls except for *a* and *g*, with or without *e*, and the argillic horizon is continuous throughout each pedon.

Argic Pachic Cryoborolls are like Typic Cryoborolls except for *a* and *e*, with or without *c*.

Argic Vertic Cryoborolls are like Typic Cryoborolls except for *a* and *l*, with or without any or all of *c*, *e*, and *k*.

Boralfic Cryoborolls are like Typic Cryoborolls except for *a* and *i*, with or without *e*.

Boralfic Lithic Cryoborolls are like Typic Cryoborolls except for *a*, *g*, and *i*, with or without *d* or *e*, or both.

Calcic Cryoborolls are like Typic Cryoborolls except for *d*.

Calcic Pachic Cryoborolls are like Typic Cryoborolls except for *d* and *e*, with or without *a* or *c*, or both.

Cumulic Cryoborolls are like Typic Cryoborolls except for *e* and *k* or for *c*, *e*, and *k*.

Duric Cryoborolls are like Typic Cryoborolls except for *j* or for *j* and *a*.

Lithic Cryoborolls are like Typic Cryoborolls except for *g*, with or without any or all of *d*, *e*, and *h*.

Lithic Ruptic-Argic Cryoborolls are like Typic Cryoborolls except for *a* and *g*, and the argillic horizon is intermittent in each pedon.

Lithic Ruptic-Entic Cryoborolls are like Typic Cryoborolls except for *g* and *f*, with or without *h*.

Natric Cryoborolls are like Typic Cryoborolls except for *a*, with or without *i*, and have an SAR $\geq$13 (or $\geq$15 percent saturation with exchangeable sodium) in the major part of the argillic horizon.

Pachic Cryoborolls are like Typic Cryoborolls except for *e*, with or without *c*.

Pergelic Cryoborolls are like Typic Cryoborolls except for *h*.

Vertic Cryoborolls are like Typic Cryoborolls except for *l*, with or without all or any of *c*, *e*, or *k*.

Haploborolls

Distinctions between Typic Haploborolls and other subgroups

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick,

that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of the bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained, or if undrained, are not continuously saturated with water in the mottled horizon for as long as 90 days in most years;

c. Have both the following:

(1) Either or both:

(a) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm thick; or

(b) A moisture control section that is dry in some part less than six-tenths of the time that the soil temperature at a depth of 50 cm is above 5°C in most years; and

(2) A chroma, moist, after rubbing of 1.5 or more in the upper part of the mollic epipedon after it has been mixed to a depth of 18 cm or in any Ap horizon that is >18 cm thick, and the soil is dry in all parts of the moisture control section at some time in most years;

d. Have a cambic horizon, or the lower part of the mollic epipedon meets the requirements of a cambic horizon except for color and organic-carbon content;

e. Have a regular decrease in organic carbon content with increasing depth and unless a lithic or a paralithic contact is at some depth between 50 cm and 1.25 m below the soil surface, have an organic carbon content of 0.3 percent or less at a depth within 1.25 m of the surface; or the slope is >25 percent; and

f. Do not have a lithic contact within 50 cm of the surface;

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and that are at least 30 cm long in some part and that extend upward to the surface or to the base of an Ap horizon;

(2) Potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

h. Do not have a salic horizon that has its upper boundary within 75 cm of the surface; and

i. Have a mollic epipedon <40 cm thick, or the epipedon has a sandy particle-size class in the major part, or there is a paralithic contact or a sandy contrasting layer between depths of 40 and 50 cm.

Aquic Haploborolls are like Typic Haploborolls except for *b,* with or without *c* or *d,* or both.

Aridic Haploborolls are like Typic Haploborolls except for all or part of *c(1)*.

Cumulic Haploborolls are like Typic Haploborolls except for *i* and *e*, with or without all or any of *b*, *d*, and *c(1)*, and have a concave shape.

Cumulic Udic Haploborolls are like Typic Haploborolls except for *i*, *e*, and *c(2)*, with or without *b* or *d*, or both, and have a concave shape.

Entic Haploborolls are like Typic Haploborolls except for *d*.

Fluvaquentic Haploborolls are like Typic Haploborolls except for *b* and *e*, with or without either *d* or *c*, or both.

Fluventic Haploborolls are like Typic Haploborolls except for *e*, with or without *d*.

Lithic Haploborolls are like Typic Haploborolls except for *f*, with or without any or all of *c*,*d*, or *i*.

Pachic Haploborolls are like Typic Haploborolls except for *i*, with or without any or all of *b*, *d*, or *c(1)*.

Pachic Udic Haploborolls are like Typic Haploborolls except for *i* and *c(2)*, with or without *b* or *d*, or both.

Ruptic-Lithic Haploborolls are like Typic Haploborolls except for *f*, with or without *d*, and bedrock is within a depth of 50 cm in part of each pedon.

Torrifluventic Haploborolls are like Typic Haploborolls except for *e* and *c(1)*, with or without *d*.

Torriorthentic Haploborolls are like Typic Haploborolls except for all or part of *c(1)*, and *d*.

Udertic Haploborolls are like Typic Haploborolls except for *c(2)* and *g*, with or without any or all or *c(1)(b)*, *e*, or *i*.

Udic Haploborolls are like Typic Haploborolls except for *c(2)*.

Udorthentic Haploborolls are like Typic Haploborolls except for *c(2)* and *d*.

Vertic Haploborolls are like Typic Haploborolls except for *g*, with or without any or all of *c(1)(b)*, *e*, or *i*.

Natriborolls

Distinctions between Typic Natriborolls and other subgroups

Typic Natriborolls are the Natriborolls that

a. Do not have tonguing or interfingering of an albic horizon more than 2.5 cm into the natric horizon;

b. Have

(1) Either or both

(a) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm; or

(b) A moisture control section that is dry in some part less than six-tenths of the time that the soil temperature at a depth of 50 cm is above 5° C in most years; or

(2) A chroma, moist, after rubbing, of 1.5 or more in the upper part of the mollic epipedon to a depth of 18 cm, after mixing, or in any Ap horizon that is more than 18 cm thick; and

c. Do not have visible crystals or nests of gypsum or more soluble salts wtihin 40 cm of the surface of the soil.

Aridic Natriborolls are like Typic Natriborolls except for *b(1)*.

Glossic Natriborolls are like Typic Natriborolls except for *a*.

Glossic Udic Natriborolls are like Typic Natriborolls except for *a* and *b(2)*.

Leptic Natriborolls are like Typic Natriborolls except for *c* or for *b* and *c*.

Udic Natriborolls are like Typic Natriborolls except for *b(2)*.

Paleborolls

Distinctions between Typic Paleborolls and other subgroups

Typic Paleborolls are the Paleborolls that

a. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below its upper boundary;

b. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or, if undrained, are not continuously saturated with water in the mottled horizon for as long as 90 days in most years;

c. Have a mean summer soil temperature at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, of 15° C or higher if there is no O horizon and 8° C or higher if there is an O horizon; and

d. Have a mollic epipedon that is <50 cm thick.

Abruptic Cryic Paleborolls are like Typic Paleborolls except for *a* and *c*, with or without *b*.

Cryic Paleborolls are like Typic Paleborolls except for *c*.

Cryic Pachic Paleborolls are like Typic Paleborolls except for *c* and *d*, with or without *b*.

Pachic Paleborolls are like Typic Paleborolls except for *d*, with or without *b*.

Vermiborolls

Distinctions between Typic Vermiborolls and other subgroups

Typic Vermiborolls are the Vermiborolls that

a. Have a mollic epipedon 75 cm or more thick;

b. Have

(1) Either or both

(a) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm thick; or

(b) A moisture control section that is dry in some part less than six-tenths of the time that the soil temperature at a depth of 50 cm is above 5° C in most years; and

(2) A chroma, moist, after rubbing, of 1.5 or more in the upper part of the mollic epipedon to a depth of 18

cm, after mixing, or in any Ap horizon that is more than 18 cm thick; and

c. Do not have a lithic contact within 50 cm of the surface.

Haplic Vermiborolls are like Typic Vermiborolls except for *a*.

Hapludic Vermiborolls are like Typic Vermiborolls except for *a* and *b(2)*.

RENDOLLS

Distinctions between Typic Rendolls and other subgroups

Typic Rendolls are the Rendolls that

a. Have a soil temperature regime warmer than cryic;

b. Do not have a cambic horizon throughout the pedon;

c. Do not have a lithic contact within 50 cm of the surface; and

d. Do not have the followng combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and

(3) More than 35 percent clay in horizons that total $>$50 cm in thickness.

e. Have a dry color value of 5.5 or less after the surface soil to a depth of 18 cm has been mixed or of any Ap horizon that is deeper than 18 cm.

Cryic Rendolls are like Typic Rendolls except for *a*.

Cryic Lithic Rendolls are like Typic Rendolls except for *a* and *c* or for *a, b,* and *c*.

Entic Rendolls are like Typic Rendolls except for *e*.

Eutrochreptic Rendolls are like Typic Rendolls except for *b*, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5°C or more.

Eutropeptic Rendolls are like Typic Rendolls except for *b* and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by $<$5°C.

Lithic Rendolls are like Typic Rendolls except for *c*.

Vertic Rendolls are like Typic Rendolls except for *d*.

UDOLLS

Key to great groups

GGA. Udolls that have an argillic horizon and a clay distribution such that the clay content does not decrease by as much as 20 percent of the maximum clay content within 1.5 m of the soil surface and there is no

lithic or paralithic contact within that depth, and there is one or both of the following features:

1. Hue redder than 10YR and chroma greater than 4 dominant in the matrix in at least the lower part of an argillic horizon; or

2. Many coarse mottles that have hue redder than 7.5YR or chroma greater than 5.

Paleudolls, p. 185

GGB. Other Udolls that have an argillic horizon.

Argiudolls, p. 183

GGC. Other Udolls that have a mollic epipedon that, below any Ap horizon, is 50 percent or more by volume wormholes, wormcasts, or filled animal burrows and that either rests on a lithic contact or has a transition to an underlying horizon in which 25 percent or more of the material is discrete wormholes, wormcasts, or filled animal burrows that contain material from the mollic epipedon and from the underlying horizon.

Vermudolls, p. 185

GGD. Other Udolls.

Hapludolls, p. 184

Argiudolls

Distinctions between Typic Argiudolls and other subgroups

Typic Argiudolls are the Argiudolls that

a. Do not have mottles within 40 cm of the surface if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificially drained; and have a horizon 15 cm or more thick immediately below the mollic epipedon that either

(1) Has a hue of 10YR or redder and chroma of 3 or more, and does not have mottles that have chroma of 2 or less and value of 4 or more if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificailly drained; or

(2) Has a hue of 2.5Y or redder and chroma of 4 or more;

b. Do not have a lithic contact within 50 cm of the surface;

c. Have texture finer than loamy fine sand in the argillic horizon, or the argillic horizon does not consist entirely of lamellae with a combined thickness of <15 cm;

d. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

e. Have CEC (by NH_4OAc) of >24 meq per 100 g clay.

Aquic Argiudolls are like Typic Argiudolls except for *a*.

Lithic Argiudolls are like Typic Argiudolls except for *b*.

Oxic Argiudolls are like Typic Argiudolls except for *e*.

Psammentic Argiudolls are like Typic Argiudolls except for *c*.

Vertic Argiudolls are like Typic Argiudolls except for *d* with or without *a*.

Hapludolls

Distinctions between Typic Hapludolls and other subgroups

Typic Hapludolls are the Hapludolls that

a. Do not have mottles within 40 cm of the surface if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificially drained; and have a horizon 15 cm or more thick immediately below the mollic epipedon that either

(1) Has a hue of 10YR or redder and chroma of 3 or more, and does not have mottles that have chroma of 2 or less and value of 4 or more if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificially drained, or

(2) Has a hue of 2.5 Y or redder and chroma of 4 or more;

b. Have a mollic epipedon $<$60 cm thick or texture that is loamy fine sand or coarser if the mollic epipedon is $\geq$60 cm thick;

c. Have a cambic horizon, or the lower part of the mollic epipedon meets the requirements of a cambic horizon except for color value and organic carbon content, and either the cambic horizon or the lower part of the epipedon is free of carbonates in some part;

d. Have a regular decrease in organic carbon content with increasing depth and unless a lithic or a paralithic contact is at some depth between 50 cm and 1.25 m below the soil surface, have an organic carbon content of 0.3 percent or less at a depth within 1.25 m of the surface, or the slope is $>$25 percent; and

e. Do not have a lithic contact within 50 cm of the surface; and

f. Do not have the following combination of characteristics;

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total $>$50 cm in thickness.

Aquic Hapludolls are like Typic Hapludolls except for *a*.

Cumulic Hapludolls are like Typic Hapludolls except for *b* and *d*, with or without *a* or *c*, or both.

Entic Hapludolls are like Typic Hapludolls except for *c*.

Fluvaquentic Hapludolls are like Typic Hapludolls except for *a* and *d* or for *a,c,* and *d*.

Fluventic Hapludolls are like Typic Hapludolls except for *d* or for *c* and *d*.

Lithic Hapludolls are like Typic Hapludolls except for *e*, with or without *a* or *c*, or both.

Vermic Hapludolls are like Typic Hapludolls except for *b* and *c* and have mollic epipedon that, below any Ap horizon, has 50 percent or more by volume of wormholes, wormcasts, or filled animal burrows.

Vertic Hapludolls are like Typic Hapludolls except for *f*, with or without all or any of *a*, *b*, and *d*.

Paleudolls

Distinctions between Typic Paleudolls and other subgroups

Typic Paleudolls are the Paleudolls that

a. Do not have mottles that have chroma of 2 or less in the upper 50 cm of the argillic horizon if the mottled horizon is saturated with water at some period when its temperature is >5° C or if the soil has artificial drainage.

Aquic Paleudolls are like Typic Paluedolls except for *a*.

Vermudolls

Distinctions between Typic Vermudolls and other subgroups

Typic Vermudolls are the Vermudolls that

a. Have a mollic epipedon that is 75 cm or more thick;

b. Do not have a cambic horizon;

c. Have a mollic epipedon that has a transition to the underlying horizon in which 50 percent or more of the material is discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and the underlying horizon;

d. Do not have a lithic contact within 50 cm of the surface; and

e. Have a mollic epipedon that below any Ap horizon has granular structure formed mainly from wormholes, wormcasts, or filled animal burrows.

Entic Vermudolls are like Typic Vermudolls except for *a*.

Haplic Vermudolls are like Typic Vermudolls except for *b* and *c*, with or without *a*.

Lithic Vermudolls are like Typic Vermudolls except for *d* and *a*, with or without *c*.

USTOLLS

Key to great groups

GFA. Ustolls that have a duripan with its upper boundary within 1 m of the soil surface.

Durustolls, p. 189

GFB. Other Ustolls that have a natric horizon.

Natrustolls, p. 191

GFC. Other Ustolls that have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface, and that have an argillic horizon or are noncalcareous in some subhorizon above the petrocalcic horizon after the surface soil to a depth of 18 cm has been mixed, or that have an argillic horizon that has one or both of the following:

1. A vertical clay distribution such that the clay content does not decrease by as much as 20 percent of the maximum clay content within 1.5 m of the soil surface and the soil does not have a lithic or paralithic contact within that depth, and the argillic horizon has one or both of these:

a. A hue redder than 10YR and chroma higher than 4 in the matrix; or

b. Common coarse mottles that have a hue of 7.5YR or redder or chroma higher than 5; or

2. A particle-size class in the upper part that is clayey and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary, and there is no lithic or paralithic contact within 50 cm of the surface of the soil.

Paleustolls, p. 192

GFD. Other Ustolls that do not have an argillic horizon above a calcic, gypsic, or petrocalcic horizon, and that have a calcic or gypsic horizon that has its upper boundary within 1.5 m of the surface, and that are calcareous in all overlying subhorizons after the upper soil to a depth of 18 cm has been mixed, unless the texture is coarser than loamy very fine sand or very fine sand.

Calciustolls, p. 188

GFE. Other Ustolls that have an argillic horizon.

Argiustolls, p. 186

GFF. Other Ustolls that have a mollic epipedon below any Ap horizon that is 50 percent or more by volume wormholes and wormcasts or filled animal burrows, and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete wormcasts or animal burrows filled with material from the mollic epipedon and the underlying horizon.

Vermustolls, p. 194

GFG. Other Ustolls.

Haplustolls, p. 189

Argiustolls

Distinctions between Typic Argiustolls and other subgroups

Typic Argiustolls are the Argiustolls that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if artificially drained or, if undrained, are not continuously saturated with water within 1 m of the soil surface for as long as 3 months in most years;

b. Do not have a brittle horizon 15 cm or more thick within 1 m of the soil surface that contains some opal coatings or some (<20 percent by volume) durinodes;

c. Do not have a lithic contact within 50 cm of the surface;

d. Do not have an albic horizon or other eluvial horizon

above the argillic horizon that has a color value too high for a mollic epipedon and chroma too high for an albic horizon;

e. Have a mollic epipedon <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is >50 cm thick;

f. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, within a depth of 90 cm if the weighted average class is loamy, and 70 cm if it is clayey, and do not have a udic moisture regime;

g. Do not have either of the following combinations of characteristics:

(1) Either

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

(c) More than 35 percent clay in horizons that total >50 cm in thickness;

(2) Or

(a) A lithic or paralithic contact or a layer of altered rock that retains its rock structure within 50 cm of the surface, and

(b) Horizons totaling 25 cm or more in thickness that contain 35 percent or more clay that has montmorillonitic mineralogy or that has a COLE ≥0.07; and

h. When neither irrigated nor fallowed to store moisture,

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm is higher than 5° C, or

(2) If the soil temperature regime is hyperthermic, or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm is higher than 8° C.

Alfic Lithic Argiustolls are like Typic Argiustolls except for *c* and *d*, with or without *f* or *h*, or both.

Aquic Argiustolls are like Typic Argiustolls except for *a* or for *a* and *f*.

Aridic Argiustolls are like Typic Argiustolls except for *h* or for *h* and *f*.

Boralfic Argiustolls are like Typic Argiustolls except for *d*, with or without all or any of *a*, *f*, or *h*, and the mean annual soil temperature is lower than 10° C.

Lithic Argiustolls are like Typic Argiustolls except for *c*, with or without *f* or *h*, or both.

Lithic Vertic Argiustolls are like Typic Argiustolls except for *c* and *g(2)*.

Pachic Argiustolls are like Typic Argiustolls except for *e*, with or without *a* or *f*, or both.

Torrertic Argiustolls are like Typic Argiustolls except for *g(1)*, with or without *e*, *f*, or *h*, and the cracks are open 6 months or more in most years.

Udic Argiustolls are like Typic Argiustolls except for *f*.

Ustalfic Argiustolls are like Typic Argiustolls except for *d* with or without *a*, *f*, and *h*, and the mean soil temperature is 10° C or more.

Vertic Argiustolls are like Typic Argiustolls except for *g*, with or without all or any of *a*, *e*, or *f*, and the cracks are open less than 6 months in most years.

Calciustolls

Distinctions between Typic Calciustolls and other subgroups

Typic Calciustolls are the Calciustolls that

a. Do not have mottles within 75 cm of the surface that are due to segregation of iron or manganese accompanied by seasonal ground water and, if undrained, are not continuously saturated with water for as long as 90 days within 1 m of the surface;

b. When neither irrigated nor fallowed to store moisture

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C, or

(2) If the soil temperature regime is hyperthermic or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a mollic epipedon that is <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

e. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface;

f. Do not have a salic horizon that has its upper boundary within 75 cm of the surface; and

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in

the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Calciustolls are like Typic Calciustolls except for *a* or for *a* and *b*.

Aridic Calciustolls are like Typic Calciustolls except for *b*.

Lithic Calciustolls are like Typic Calciustolls except for *c* or for *b* and *c*.

Pachic Calciustolls are like Typic Calciustolls except for *d*, with or without *a*.

Petrocalcic Calciustolls are like Typic Calciustolls except for *e* or for *b* and *e*.

Torrertic Calciustolls are like Typic Calciustolls except for *g*, with or without any or all of *a*, *b*, and *d*, and the cracks are open 180 days or more, cumulative, in most years.

Vertic Calciustolls are like Typic Calciustolls except for *g*, with or without any or all of *a*, *b*, and *d*, and the cracks are open less than 180 days, cumulative, in most years.

Durustolls

These are the Ustolls that have a duripan that has its upper boundary within 1 m of the soil surface. They are not known to occur in the United States, and subgroups have not been developed. They are probably rare in the world. They had no clear equivalent in the 1938 classification.

Haplustolls

Distinctions between Typic Haplustolls and other subgroups

Typic Haplustolls are the Haplustolls that

a. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or, if undrained, are not continuously saturated with water within 1 m of the soil surface for 90 days or more in most years;

b. Have a mollic epipedon that is <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

c. Do not have a brittle horizon 15 cm or more thick within 1 m of the surface that contains some opal coatings or some durinodes (<20 percent by volume);

d. Have a cambic horizon, or the lower part of the mollic epipedon meets the requirements of a cambic horizon except for color and for organic-carbon content, and either the cambic horizon or the lower part of the mollic epipedon is free of carbonates in some part;

e. Have a regular decrease in organic-carbon content with increasing depth to a level of 0.3 percent or less within 1.25 m of the surface unless a lithic or paralithic contact occurs at a shallower depth or the slope is >25 percent;

f. Do not have a lithic contact within 50 cm of the surface;

g. Do not have a salic horizon that has its upper boundary within 75 cm of the surface;

h. Do not have either of the following combinations of characteristics:

(1) Do not have any of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; or

(c) More than 35 percent clay in horizons that total $>$50 cm in thickness; and

(2) Do not have both of the following:

(a) A lithic or paralithic contact or altered rock that retains its rock structure within 50 cm of the surface, and

(b) Horizons totaling 25 cm or more in thickness that have 35 percent or more clay and montmorillonitic mineralogy or a COLE $\geq$ 0.07;

i. In addition

(1) Have a calcic horizon or soft, powdery secondary lime within a depth of 90 cm of the surface if the weighted average particle-size class of all horizons between a depth of 25 cm and 1 m, or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m, is loamy, within 1.25 m if the particle-size class is sandy, and within 70 cm if it is clayey; and

(2) Do not have a udic moisture regime;

j. When neither irrigated nor fallowed to store moisture,

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C, or

(2) If the soil temperature regime is hyperthermic or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C; and

k. Have 24 meq or more CEC per 100 g clay (by NH_4OAc) and have a cation-retention capacity from NH_4Cl of 12 or more meq per 100 g clay in the major part of the soil below a depth of 25 cm but above 1 m or a lithic or paralithic contact if one is shallower than 1 m.

Aquic Haplustolls are like Typic Haplustolls except for *a,* with or without *d* or *i,* or both.

Aridic Haplustolls are like Typic Haplustolls except for *j* or for *i(1)* and *j.*

Cumulic Haplustolls are like Typic Haplustolls except for *b* and *e,* with or without all or any of *a, d, i,* and *j.*

Entic Haplustolls are like Typic Haplustolls except for *d* and either do not have a cambic horizon or the epipedon is calcareous.

Fluvaquentic Haplustolls are like Typic Haplustolls except for *a* and *e*, with or without *d* or *i*, or both.

Fluventic Haplustolls are like Typic Haplustolls except for *e*, with or without *d* or *i*, or both.

Lithic Haplustolls are like Typic Haplustolls except for *f*, with or without any or all of *d*, *i(1)*, and *j*.

Lithic Ruptic-Entic Haplustolls are like Typic Haplustolls except for *f* and *d* and have a cambic horizon in some part but in less than half of each pedon.

Lithic Vertic Haplustolls are like Typic Haplustolls except for *f* and *h(2)*, with or without *d* or *i*, or both, and have a lithic contact.

Oxic Haplustolls are like Typic Haplustolls except for *k*, with or without *b* or *e*, or both.

Pachic Haplustolls are like Typic Haplustolls except for *b*, with or without all or any of *a*, *d*, or *i*.

Paralithic Vertic Haplustolls are like Typic Haplustolls except for *h(2)*, with or without *d* or *i* or both, and have a paralithic contact or altered rock that retains its rock structure.

Ruptic-Lithic Haplustolls are like Typic Haplustolls except for *f* in part of each pedon.

Salorthidic Haplustolls are like Typic Haplustolls except for *g*, with or without all or any of *a*, *b*, *e*, *i*, or *j*.

Torrertic Haplustolls are like Typic Haplustolls except for *h(1)*, with or without all or any of *b*, *d*, *e*, *i*, or *j*, and the cracks are open more than 6 months in most years.

Torrifluventic Haplustolls are like Typic Haplustolls except for *e* and *j*, with or without *d* or *i(1)*, or both.

Torriorthentic Haplustolls are like Typic Haplustolls except for *d* and *j*, with or without *i(1)*.

Torroxic Haplustolls are like Typic Haplustolls except for *j* and *k*, with or without all or any or *b*, *e*, and *i*.

Udertic Haplustolls are like Typic Haplustolls except for *h(1)* and *i*, with or without all or any of *a*, *b*, *d*, *e*, or *j*, and the cracks are open less than 135 days in most years.

Udic Haplustolls are like Typic Haplustolls except for *i*.

Udorthentic Haplustolls are like Typic Haplustolls except for *d* and *i*.

Vertic Haplustolls are like Typic Haplustolls except for *h(1)*, with or without all or any of *a*, *b*, *d*, *e*, or *j*, and the cracks are open between 135 and 180 days in most years.

Natrustolls

Distinction between Typic Natrustolls and other subgroups

Typic Natrustolls are the Natrustolls that

a. Do not have any of the following characteristics within 1 m of the surface:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5 Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or

(3) Dominant chroma of 2 or less and a decrease in the percentage of exchangealbe sodium from the upper 25-centimeter layer to the underlying layer;

b. Do not have a brittle horizon 15 cm or more thick that is within 1 m of the surface and that contains some opal coatings or some durinodes (<20 percent by volume);

c. Do not have tonguing or interfingering of an albic horizon more than 2.5 cm into a natric horizon;

d. When neither irrigated not fallowed to store moisture

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some parts of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C; or

(2) If the soil temperature regime is hyperthermic, or isomesic or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C; and

e. Do not have visible crystals or nests of gypsum or more soluble salts within 40 cm of the surface.

Aridic Natrustolls are like Typic Natrustolls except for *d.*

Glossic Natrustolls are like Typic Natrustolls except for *c.*

Leptic Natrustolls are like Typic Natrustolls except for *e* or for *d* and *e.*

Paleustolls

Distinctions between Typic Paleustolls and other subgroups

Typic Paleustolls are the Paleustolls that

a. Are noncalcareous in some horizons after the upper soil to a depth of 18 cm has been mixed;

b. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or, if undrained in most years, are not continuously saturated with water in the mottled horizon for as long as 90 days;

c. Have a mollic epipedon that is <50 cm thick or have texture that is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

d. Do not have a petrocalcic horizon within 1.5 m of the surface;

e. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy; 90 cm if it is loamy, and 70 cm if it is clayey; and do not have a udic moisture regime;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

3. More than 35 percent clay in horizons that have total thickness of >50 cm; and

g. When neither irrigated nor fallowed to store moisture,

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C, or

(2) If the soil temperature regime is hyperthermic or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C.

Aquic Paleustolls are like Typic Paleustolls except for *b*.

Aridic Paleustolls are like Typic Paleustolls except for *g*.

Calcic Paleustolls are like Typic Paleustolls except for *a* and have a calcic horizon within a depth a 1 m if the particle-size class of the upper 50 cm of the argillic horizon is sandy, 60 cm if it is loamy, and 50 cm if it is clayey.

Calciorthidic Paleustolls are like Typic Paleustolls except for *a* and *g* and have a calcic horizon within a depth of 1 m if the particle-size class of the upper 50 cm of the argillic horizon is sandy, 60 cm if loamy, and 50 cm if clayey.

Pachic Paleustolls are like Typic Paleustolls except for *c*, with or without *b* or *e*, or both.

Petrocalcic Paleustolls are like Typic Paleustolls except for *d*, with or without *a* or *g*, or both, and have an argillic horizon.

Torrertic Paleustolls are like Typic Paleustolls except for *f*, with or without any or all of *c*, *e*, and *g*, and the cracks are open more than 180 days, cumulative, in most years.

Udertic Paleustolls are like Typic Paleustolls except for *e* and *f*, with or without any or all of *b*, *c*, and *g*, and the cracks are open less than 135 days, cumulative, in most years.

Udic Paleustolls are like Typic Paleustolls except for *e*.

Vertic Paleustolls are like Typic Paleustolls except for *f*, with or without any or all of *b*, *c*, and *g*, and the cracks are open between 135 and 180 days, cumulative, in most years.

Vermustolls

Distinctions between Typic Vermustolls and other subgroups

Typic Vermustolls are the Vermustolls that

a. Have a mollic epipedon that is 50 cm or more thick but is <75 cm thick;

b. Do not have a cambic horizon;

c. Have a mollic epipedon that, below any Ap horizon, has a transition to the underlying horizon in which 50 percent

or more of the volume is wormholes and wormcasts or filled animal burrows;
d. Do not have a lithic contact within 50 cm of the surface;
e. Have a mollic epipedon that has granular structure and is composed almost entirely, below any Ap horizon, of wormholes, wormcasts, or filled animal burrows; and
f. Do not have mottles that have chroma of 2 or less within 1 m of the surface.

Entic Vermustolls are like Typic Vermustolls except for *a,* and the epipedon is <50 cm thick.

Haplic Vermustolls are like Typic Vermustolls except for *b* and *c,* with or without *a,* and the epipedon is <75 cm thick.

Lithic Vermustolls are like Typic Vermustolls except for *d* and *a,* with or without *b* or *c,* or both, and the epipedon is <75 cm thick.

Pachic Vermustolls are like Typic Vermustolls exept for *a,* and the epipedon is 75 cm or more thick.

XEROLLS

Key to great groups

GDA. Xerolls that have a duripan within 1 m of the soil surface.

Durixerolls, p. 197

GDB. Other Xerolls that have a natric horizon but do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface.

Natrixerolls, p. 200

GDC. Other Xerolls that have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface or an argillic horizon that has either or both

1. A vertical clay distribution such that the clay content does not decrease by as much as 20 percent of the maximum clay content within 1.5 m of the soil surface, and also one or more of

a. A hue redder than 10YR and chroma higher than 4 in the matrix; or

b. Common coarse mottles that have a hue of 7.5YR or redder or chroma higher than 5, or both; or

2. A particle-size class in the upper part that is clayey and an increase in clay content of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or an increase of 15 percent clay (absolute) within a distance of 2.5 cm at the upper boundary and no lithic or paralithic contact within 50 cm of the soil surface.

Palexerolls, p. 200

GDD. Other Xerolls that have a calcic or gypsic horizon that has its upper boundary within 1.5 m of the soil surface and that are calcareous in all parts of all horizons above the calcic or gypsic horizon after the upper soil to a depth of 18 cm has been mixed unless the texture is coarser than loamy very fine sand or very fine sand.

Calcixerolls, p. 196

GDE. Other Xerolls that have an argillic horizon.

Argixerolls, p. 195

GDF. Other Xerolls.

Haploxerolls, p. 197

Argixerolls

Distinctions between Typic Argixerolls and other subgroups

Typic Argixerolls are the Argixerolls that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the surface if artificially drained or if undrained are not continuously saturated with water within 1 m of the soil surface for 90 days or more in most years;

b. Do not have an albic horizon above the argillic horizon;

c. Do not have a calcic horizon or soft, powdery secondary lime within a depth of 1.5 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, 1.1 m if it is loamy, and 90 cm if it is clayey, or above a lithic contact that is shallower than these depths;

d. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

e. Do not have a lithic contact within 50 cm of the soil surface;

f. Have a xeric moisture regime;

g. Have a mollic epipedon that is <50 cm thick or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

h. Have base saturation (by sum of cations) of >75 percent throughout the upper 75 cm or above a lithic or paralithic contact, whichever is shallower; and

i. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallowr than 1.5 m, and

(3) More than 35 percent clay in horizons that have a total thickness of >50 cm.

Aquic Argixerolls are like Typic Argixerolls except for *a*, with or without *c*.

Aquultic Argixerolls are like Typic Argixerolls except for *a* and *h*.

Aridic Argixerolls are like Typic Argixerolls except for *f* and they have an aridic moisture regime that borders on xeric.

Aridic Calcic Argixerolls are like Typic Argixerolls except for *c* and *f*, and they have an aridic moisture regime that borders on xeric.

Boralfic Argixerolls are like Typic Argixerolls except for *b*, with or without all or any of *c*, *g*, or *h*, and the mean annual soil temperature is lower than 10°C.

Calcic Argixerolls are like Typic Argixerolls except for *c*.

Calcic Pachic Argixerolls are like Typice Argixerolls except for *c* and *g*, with or without *a*.

Durargidic Argixerolls are like Typic Argixerolls except for *d* and *f*.

Duric Argixerolls are like Typic Argixerolls except for *d*, with or without *c*.

Lithic Argixerolls are like Typic Argixerolls except for *e*, with or without *c* or *f*, or both.

Lithic Ultic Argixerolls are like Typic Argixerolls except for *e* and *h*.

Pachic Argixerolls are like Typic Argixerolls except for *g*, with or without *a*.

Pachic Ultic Argixerolls are like Typic Argixerolls except for *g* and *h*, with or without *a*.

Ultic Argixerolls are like Typic Argixerolls except for *h*.

Vertic Argixerolls are like Typic Argixerolls except for *i*, with or without all or any of *a*, *c*, or *g*.

Calcixerolls

Distinctions between Typic Calcixerolls and other subgroups

Typic Calcixerolls are the Calcixerolls that

a. Do not have mottles within 75 cm of the surface that are due to segregation of iron or manganese if artificially drained, and if undrained are not continuously saturated with water within 1 m of the soil surface for as long as 90 days in most years;

b. Have a mollic epipedon that is <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≥ 50 cm thick;

c. Have a xeric moisture regime;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Do not have a mollic epipedon that below any Ap horizon has 50 percent or more by volume wormholes, wormcasts, or filled animal burrows; and

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that have a total thickness of >50 cm.

Aquic Calcixerolls are like Typic Calcixerolls except for *a*.

Aridic Calcixerolls are like Typic Calcixerolls except for *c* and have an aridic moisture regime that borders on xeric.

Lithic Calcixerolls are like Typic Calcixerolls except for *d* or for *c* and *d*.

Pachic Calcixerolls are like Typic Calcixerolls except for *b* or for *a* and *b*, with or without *c*.

Vermic Calcixerolls are like Typic Calcixerolls except for *e*.

Vertic Calcixerolls are like Typic Calcixerolls except for *f*, with or without *a* or *b*, or both.

Durixerolls

Distinctions between Typic Durixerolls and other subgroups

Typic Durixerolls are the Durixerolls that

a. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm or an increase of 15 percent or more (absolute) within a distance of 2.5 cm at the upper boundary;

b. Have a duripan that is massive, platy, or prismatic and that has half or more of its upper boundary indurated or coated with opal or opal and sesquioxides or that is indurated in some subhorizon below its upper boundary;

c. Have an argillic horizon above the duripan;

d. Have a xeric moisture regime; and

e. Do not have mottles that have chroma of 2 or less above the duripan.

Abruptic Aridic Durixerolls are like Typic Durixerolls except for *a* and *d* and have an aridic moisture regime that borders on xeric.

Argic Durixerolls are like Typic Durixerolls except for *b*.

Aridic Durixerolls are like Typic Durixerolls except for *d* and have an aridic moisture regime that borders on xeric.

Entic Durixerolls are like Typic Durixerolls except for *b* and *c*.

Haplic Durixerolls are like Typic Durixerolls except for *c*.

Orthidic Durixerolls are like Typic Durixerolls except for *c* and *d* and have an aridic moisture regime that borders on xeric.

OLL

Haploxerolls

Distinctions between Typic Haploxerolls and other subgroups

Typic Haploxerolls are the Haploxerolls that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the surface if artificially drained and if undrained, are not continuously saturated with water within 1 m of the soil surface for 90 days or more in most years;

b. Do not have a calcic horizon or soft, powdery secondary lime within a depth of 1.5 m if the weighted average particle-size class of all horizons between a depth of 25 cm and 1 m, or between a depth of 25 cm and a lithic or paralithic contact that is shallower than 1 m, is sandy;

within 1.1 m if the average particle-size class is loamy; or within 90 cm if it is clayey;
c. Have a mollic epipedon that is <50 cm thick or texture that is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;
d. Do not have a horizon within 1 m of the surface that is > 15 cm thick that either contains at least 20 percent duri-nodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
e. Have a cambic horizon, or the lower part of the epipedon meets the requirements of a cambic horizon except for color value, and either the cambic horizon or the lower part of the epipedon is free of carbonates in some part;
f. Have a regular decrease in organic carbon content with increasing depth and unless a lithic or a paralithic contact is at some depth between 50 cm and 1.25 m below the soil surface, have an organic carbon content of 0.3 percent or less at a depth within 1.25 m of the surface; or the slope is >25 percent;
g. Do not have a lithic contact within 50 cm of the soil surface;
h. Have base saturation (by sum of cations) of >75 percent throughout the upper soil to a depth of 75 cm or above a lithic or paralithic contact, whichever is shallower;
i. Do not have a mollic epipedon that has granular structure and that, below any Ap horizon, has 50 percent or more by volume or wormholes, wormcasts, or filled animal burrows;
j. Do not have either of the following combinations of characteristics:

(1) Either

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(c) More than 35 percent clay in horizons that have a total thickness of > 50 cm;

(2) Or

(a) A lithic or paralithic contact or altered rock that retains its rock structure within 50 cm of the soil surface, and

(b) Horizons that have a total thickness of 25 cm or more and that have 35 percent or more clay and montmorillonitic mineralogy or that have a COLE ≥0.05; and

k. Have a xeric moisture regime.

Aquic Haploxerolls are like Typic Haploxerolls except for *a,* with or without *b* or *e,* or both.

Aquic Duric Haploxerolls are like Typic Haploxerolls except for *a* and *d*, with or without all or any of *b*, *e*, or *f*.

Aqultic Haploxerolls are like Typic Haploxerolls except for *a* and *h*, with or without *e*.

Aridic Haploxerolls are like Typic Haploxerolls except for *k* or for *h* and *k* and have an aridic moisture regime that borders on xeric.

Aridic Duric Haploxerolls are like Typic Haploxerolls except for *d* and *k*, with or without all or any of *b*, *e*, or *h*, and have an aridic moisture regime that borders on xeric.

Calcic Haploxerolls are like Typic Haploxerolls except for *b* or for *b* and *e*.

Calcic Pachic Haploxerolls are like Typic Haploxerolls except for *b* and *c*, with or without *a* or *e*, or both.

Calciorthidic Haploxerolls are like Typic Haploxerolls except for *b* and *k*, with or without *e*, and have an aridic moisture regime.

Cumulic Haploxerolls are like Typic Haploxerolls except for *c* and *f*, with or without all or any of *a*, *b*, *e*, and *k*.

Cumulic Ultic Haploxerolls are like Typic Haploxerolls except for *c*, *f*, and *h*, with or without all or any of *a*, *b*, or *e*.

Entic Haploxerolls are like Typic Haploxerolls except for *e*.

Entic Ultic Haploxerolls are like Typic Haploxerolls except for *e* and *h*.

Fluvaquentic Haploxerolls are like Typic Haploxerolls except for *a* and *f*, with or without *b* or *e*, or both.

Fluventic Haploxerolls are like Typic Haploxerolls except for *f*, with or without *b* or *e*, or both.

Lithic Haploxerolls are like Typic Haploxerolls except for *g*, with or without all or any of *e*, *b*, or *k*.

Lithic Ultic Haploxerolls are like Typic Haploxerolls except for *g* and *h*, with or without *e*.

Pachic Haploxerolls are like Typic Haploxerolls except for *c*, with or without all or any of *a*, *e*, or *k*.

Pachic Ultic Haploxerolls are like Typic Haploxerolls except for *c* and *h*, with or without *a* or *e*, or both.

Torrertic Haploxerolls are like Typic Haploxerolls except for *j(1)* and *k*, with or without all or any of *a*, *b*, *c*, or *f*.

Torrifluventic Haploxerolls are like Typic Haploxerolls except for *f* and *k*, with or without all or any of *b*, *e*, or *h*.

Torriorthentic Haploxerolls are like Typic Haploxerolls except for *e* and *k*, with or without *h*, and they do not have a sandy particle-size class in all subhorizons to a depth of 1 m.

Torripsammentic Haploxerolls are like Typic Haploxerolls except for *e* and *k*, with or without *h*, and they have a sandy particle-size class in all subhorizons to a depth of 1 m or more.

Ultic Haploxerolls are like Typic Haplxerolls except for *h*.

Vermic Haploxerolls are like Typic Haploxerolls except for *i*, with or without *b*.

Vertic Haploxerolls are like Typic Haploxerolls except for *j(1)*, with or without all or any or *a*, *b*, *c*, or *f*.

Natrixerolls

Distinctions between Typic Natrixerolls and other subgroups

Typic Natrixerolls are the Natrixerolls that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist; and

c. Have a xeric moisture regime.

Aquic Natrixerolls are like Typic Natrixerolls except for *a*.

Aquic Duric Natrixerolls are like Typic Natrixerolls except for *a* and *b*.

Aridic Natrixerolls are like Typic Natrixerolls except for *c*, and have an aridic moisture regime that borders on xeric.

Duric Natrixerolls are like Typic Natrixerolls except for *b*.

Palexerolls

Distinctions between Typic Palexerolls and other subgroups

Typic Palexerolls are Palexerolls that

a. Have an argillic horizon that has a clayey particle-size class in the upper part and an increase in clay content of 20 percent clay (absolute) or more within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within a distance of 2.5 cm at the upper boundary;

b. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface;

c. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface;

d. Have a mollic epipedon that is <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

e. Do not have a natric horizon;

f. Have base saturation of >75 percent throughout the argillic horizon or in the upper 50 cm of the argillic horizon, whichever is thinner;

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or a paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that have a total thickness of >50 cm; and

h. Have a xeric moisture regime.

Aridic Palexerolls are like Typic Palexerolls except for *h* and have an aridic moisture regime that borders on xeric.

Aridic Petrocalcic Palexerolls are like Typic Palexerolls except for *c* and *h,* with or without *a,* and have an aridic moisture regime that borders on xeric.

Pachic Palexerolls are like Typic Palexerolls except for *d,* with or without all or any of *a, b,* or *h.*

Petrocalcic Palexerolls are like Typic Palexerolls except for *c,* with or without *a.*

Ultic Palexerolls are like Typic Palexerolls except for *f,* with or without *a.*

[1] If the mollic epipedon extends to a lithic contact within 30 cm of the surface, the requirement for mottles is waived.

[2] If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-size lime.

[3] If there is a surface mantle that has ≥60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral soil surface.

Chapter 11
Oxisols

Key to suborders

CA. Oxisols that have one or both of the following characteristics:

1. Plinthite that forms a continuous phase within 30 cm of the mineral surface of the soil and the soil is saturated with water within this depth at some time during the year; or

2. Either are saturated with water at some time during the year or are artificially drained, have an oxic horizon, and also have one or both of the following characteristics associated with wetness:

a. A histic epipedon; or

b. If free of mottles, immediately below any epipedon that has moist color value of less than 3.5 there is dominant chroma of 2 or less; or if there are distinct or prominent mottles within 50 cm of the soil surface, the dominant chroma is 3 or less.

Aquox, p. 203

CB. Other Oxisols that have a torric moisture regime.

Torrox, p. 209

CC. Other Oxisols that:

1. Have 16 kg or more organic carbon per square meter to a depth of 1 m, exclusive of organic surface litter;

2. Have a weighted average base saturation in the oxic horizon (by NH_4OAc) of <35 percent; and

3. Have an isothermic, thermic, or cooler temperature regime.

Humox, p. 204

CD. Other Oxisols that have an ustic soil moisture regime and an isothermic, thermic, or warmer temperature regime.

Ustox, p. 209

CE. Other Oxisols.

Orthox, p. 206

AQUOX

Key to great groups

CAA. Aquox that either have cemented sheets containing 30 percent or more gibbsite or have 20 percent or more by volume gravelsize aggregates containing 30 percent or more gibbsite within 1 m of the mineral soil surface but that do not have plinthite that forms a continuous phase within 30 cm of the soil surface.

Gibbsiaquox, p. 203

CAB. Other Aquox that have plinthite that forms a continuous phase within 1.25 m of the soil surface.

Plinthaquox, p. 204

CAC. Other Aquox that have an ochric epipedon.

Ochraquox, p. 204

CAD. Other Aquox.

Umbraquox, p. 204

Gibbsiaquox

Definition

Gibbsiaquox are the Aquox that either have cemented sheets containing 30 percent or more gibbsite or have 20 percent or more by volume gravel-size aggregates containing 30 percent or more gibbsite within 1 m of the mineral soil surface but that do not have plinthite that forms a continuous phase within 30 cm of the soil surface.

Ochraquox

Definition of Typic Ochraquox

It is believed that Typic Ochraquox should be the Ochraquox that:

1. Have properties that are diagnostic of an oxic horizon, beginning at the surface or immediately below any thin surface horizon that has a color value, moist, less than 3.5, and extending to a depth of 1 m or more;

2. Do not have plinthite that forms a continuous phase within the upper 2 m; and

3. Have texture of sandy clay loam or finer throughout the oxic horizon.

Plinthaquox

Proposed distinctions between Typic Plinthaquox and other subgroups

Typic Plinthaquox are the Plinathaqox that

a. Do not have plinthite that forms a continuous phase within a depth of 30 cm;

b. Have chroma of 2 or less in some part of the matrix of the nonplinthite materials within the horizon that contains plinthite and in all overlying horizons; and

c. Have an ochric epipedon.

A superic subgroup is proposed for the Plinthaquox that have plinthite that forms a continuous phase at the soil surface or within a depth of 30 cm.

Umbraquox

Definition

Umbraquox are the Aquox that

1. Have an umbric or histic epipedon;

2. Do not have plinthite that forms a continuous phase within 1.25 m of the soil surface;

3. Have $<$20 percent by volume gravel-size aggregates that have 30 percent or more gibbsite and do not have cemented sheets that contain 30 percent or more gibbsite within 1 m of the soil surface.

Subgroups of Umbraquox have not been developed. It is believed that Typic Umbraquox should be the Umbraquox that

a. Have an oxic horizon that has texture of sandy clay loam or a finer class;

b. Have an oxic horizon that is 1 m or more thick;

c. Do not have plinthite that forms a continuous phase within 2 m of the soil surface.

HUMOX

Key to great groups

CCA. Humox that have a sombric horizon.

Sombrihumox, p. 206

CCB. Other Humox that have, within 1 m of the soil surface, either cemented sheets that have 30 percent or more gibbsite or a subhorizon that has 20 percent or more by volume gravel-size aggregates that contain 30 percent or more gibbsite.

Gibbsihumox, p. 205

CCC. Other Humox that have in all subhorizons of the oxic horizon a cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[1] or that have >1.5 meq of extractable bases plus extractable aluminum per 100 g clay.

Haplohumox, p. 205

CCD. Other Humox.

Acrohumox, p. 205

Acrohumox

Definition and description of Typic and Petroferric Acrohumox

Typic Acrohumox are the Acrohumox that

a. Have an ochric epipedon or an umbric epipedon that is <75 cm thick;

b. Have <5 percent by volume plinthite in all subhorizons within 1.25 m of the soil surface and do not have mottles that have chroma of 2 or less within 1.25 m of the soil surface;

c. Have an oxic horizon that extends to a depth of 1.25 m or more below the soil surface;

d. Have texture that is sandy clay loam or finer in the oxic horizon; and

e. Do not have a petroferric contact within 1.25 m of the soil surface.

Petroferric Acrohumox are like Typic Acrohumox except for *e*.

Gibbsihumox

Definition of Typic Gibbsihumox

Typic Gibbsihumox are the Gibbsihumox that

a. Do not have mottles that have chroma of 2 or less above the uppermost gibbsite sheet or above a depth of 1 m, whichever is shallower;

b. Have <5 percent by volume plinthite in all horizons to a depth of 1.25 m; and

c. Have gravel-size aggregates that are cemented by gibbsite within the upper 50 cm.

Haplohumox

Definition of Typic Haplohumox

It is believed that Typic Haplohumox

a. Have an ochric epipedon or an umbric epipedon that is <75 cm thick;

b. Have <5 percent plinthite by volume in all subhorizons within 1.25 m of the soil surface and should not have a dominant base color or mottles that have chroma of 2 or less within that depth;

c. Have an oxic horizon that extends to a depth of 1.25 m or more below the soil surface;
d. Have an oxic horizon that has texture that is sandy clay loam or finer; and
e. Have <4 meq of KCl-extractable aluminum per 100 g clay in the major part of the oxic horizon.

Sombrihumox

These are the Humox that have a sombric horizon in the oxic horizon. They are not known to occur in the United States but have been reported in the highlands of Africa and may be present in parts of South America. They have been little studied, and subgroups have not been developed.

ORTHOX

Key to great groups

CEA. Orthox that have a sombric horizon.

Sombriorthox, p. 208

CEB. Other Orthox that have within 1.25 m of the soil surface sheets that contain 30 percent or more gibbsite or a subhorizon that has 20 percent or more by volume gravel-size aggregates that contain 30 percent or more gibbsite.

Gibbsiorthox, p. 207

CEC. Other Orthox that

1. Have in some subhorizon of the oxic horizon a cation-retention capacity of 1.5 meq or less (from NH_4Cl) per 100 g clay[1] (or 1.5 meq or less extractable bases plus extractable aluminum per 100 g clay); and

2. Do not have discernible structure[2] in the oxic horizon or have only weak blocky or prismatic peds.

Acrorthox, p. 206

CED. Other Orthox that do not have an anthropic epipedon and have base saturation of 35 percent or more (by NH_4OAc) in the epipedon and in all subhorizons of the oxic horizon to a depth of at least 1.25 m.

Eutrorthox, p. 207

CEE. Other Orthox that have either an umbric epipedon or an ochric epipedon that has >1 percent carbon in all subhorizons to a depth of 75 cm or more below the mineral soil surface.

Umbriorthox, p. 209

CEF. Other Orthox.

Haplorthox, p. 208

Acrorthox

Distinctions between Typic Acrorthox and other subgroups

Typic Acrorthox are the Acrorthox that
a. Have <5 percent by volume of plinthite or of gravel-size aggregates that are cemented by gibbsite in all subhorizons within a depth of 1 m from the soil surface;
b. Have an oxic horizon that extends to a depth of 1.25 m or more below the soil surface;
c. Have texture that is sandy clay loam or finer in the oxic horizon to a depth at least 1 m below the soil surface.
d. Have a hue redder than 10YR in all parts of the upper 75 cm that have a color value, moist, of 4 or more if the hue in

horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron above a depth of 75 cm;
e. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and that is 60 cm or less above the horizon that has the greater percentage of clay;
f. Have a net positive charge in some subhorizon within 1.5 m of the soil surface.

Haplic Acrorthox are like Typic Acrorthox except for *f.*

Plinthic Acrorthox are like Typic Acrorthox except for *a* and *f.*

Eutrorthox

Distinctions between Typic Eutrorthox and other subgroups

These distinctions have not been completely developed. Those that can be stated are as follows.

Typic Eutrorthox are the Eutrorthox that
a. Have an oxic horizon that extends to a depth 1.25 m or more below the mineral soil surface;
b. Do not have discernible structure[3] in the major part of the oxic horizon or have only weak blocky or prismatic structure;
c. Have texture that is sandy clay loam or finer in all parts of the oxic horizon within a depth 1.25 m below the mineral soil surface;
d. Have <5 percent by volume plinthite in all subhorizons within a depth 1.25 m below the mineral soil surface;
e. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the mineral soil surface; and
f. Have <16 kg organic carbon per square meter to a depth of 1 m; and
g. Do not have a sombric horizon or a horizon that meets all the requirements for a sombric horizon except base saturation.

Haplohumic Eutrorthox are like Typic Eutrorthox except for *f.*

Sobrihumic Eutrorthox are like Typic Eutrorthox except for *f* and *g.*

Tropeptic Eutrorthox are like Typic Eutrorthox except for *a* or *b,* or both. The oxic horizon is terminated by saprolite, rock, or weatherable minerals within 1.25 m of the mineral soil surface or there is discernible structure[4] in the major part of the oxic horizon, or both.

Gibbsiorthox

Typic Gibbsiorthox are the Gibbsiorthox that
a. Have gravel-size aggregates cemented by gibbsite within the upper 50 cm; and

b. Do not have mottles that have chroma of 2 or less within the upper 1 m of the soil or above the uppermost gibbsite sheet, whichever is shallower.

Haplorthox

Distinctions between Typic Haplorthox and other subgroups

The subgroups defined and described here have been only partly developed.

Typic Haplorthox are the Haplorthox that

a. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the soil surface;

b. Have <5 percent, by volume, plinthite in all subhorizons within 1.25 m of the soil surface;

c. Have texture that is sandy-clay loam or finer in all parts of the oxic horizon within 1.25 m of the mineral soil surface;

d. Have an oxic horizon that extends to a depth 1.25 m or more below the mineral soil surface;

e. Do not have discernible structure[4] in the major part of the oxic horizon or have only weak blocky or prismatic structure;

f. Have a hue redder than 10YR in all parts of the upper 75 cm that have a color value, moist, of 4 or more if the hue in horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron within the upper 75 cm; and

g. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and is 60 cm or less above the horizon having the greater percentage of clay.

Aquic Haplorthox are like Typic Haplorthox except for *a.*

Epiaquic Haplorthox are like Typic Haplorthox except for *f.*

Plinthic Haplorthox are like Typic Haplorthox except for *b.*

Quartzipsammentic Haplorthox are like Typic Haplorthox except for *c.*

Tropeptic Haplorthox are like Typic Haplorthox except for *d* or *e* or both.

Ultic Halplorthox are like Typic Haplorthox except for *g* or for *e* and *g*.

Sombriorthox

These are the Orthox that have a sombric horizon. They are not known to occur in Puerto Rico or elsewhere in the United States but have been reported in other countries. The classification of subgroups has not been developed.

Umbriorthox

Distinctions between Typic Umbriorthox and other subgroups

Typic Umbriorthox are the Umbriorthox that

a. Have texture that is sandy clay loam or finer in all parts of the oxic horizon within 1.25 m of the mineral soil surface;

b. Have an oxic horizon that extends to a depth of 1.25 m or more below the mineral soil surface;

c. Have <5 percent by volume of plinthite in all subhorizons within 1.25 m of the mineral soil surface;

d. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the mineral soil surface.

e. Have an umbric epipedon that is <1.25 m thick and have <1 percent organic carbon in some subhorizon within 1.25 m of the mineral soil surface; and

f. In the major part of the oxic horizon, do not have discernible fine or medium granular structure or have only weak blocky or prismatic structure.

Tropeptic Umbriorthox are like Typic Umbriorthox except for any or all of *b, e,* and *f.*

TORROX

Definition

Torrox are the Oxisols that have a torric moisture regime.

The soils we know in this suborder are so similar that no subdivisions seem justified at the great group or subgroup levels. All are considered to be typic soils of the suborder.

USTOX

Key to great groups

CDA. Ustox that have a sombric horizon.

Sombriustox, p. 211

CDB. Other Ustox that have a cation-retention capacity (from NH_4Cl) of 1.5 meq or less per 100 g clay[5] in some subhorizon of the oxic horizon (or have 1.5 meq or less of extractable bases plus extractable aluminum per 100 g clay).

Acrustox, p. 209

CDC. Other Ustox that have base saturation of 50 percent or more (by NH_4OAc) in the major part of the oxic horizon if the particle-size class is clayey or 35 percent or more if the particle-size class is loamy.

Eutrustox, p. 210

CDD. Other Ustox.

Haplustox, p. 210

Acrustox

Proposed definition of Typic Acrustox

Typic Acrustox are the Acrustox that

a. Have <5 percent by volume of plinthite or of gravel-size aggregates that are cemented by gibbsite in all subhorizons within 1 m of the soil surface;
b. Have an oxic horizon that extends to a depth 1.25 m or more below the mineral soil surface;
c. Have texture in the oxic horizon that is sandy clay loam or finer to a depth at least 1 m below the mineral soil surface;
d. Have a net positive charge in some subhorizon within 1.25 m of the soil surface.

Eutrustox

Proposed distinctions between Typic Eutrustox and other subgroups

Typic Eutrustox are defined as the Eutrustox that
a. Have texture that is sandy clay loam or finer in all parts of the oxic horizon;
b. Have an oxic horizon that extends to a depth 1.25 m or more below the soil surface;
c. Have <5 percent by volume of plinthite in all subhorizons within a depth 1.25 m below the soil surface;
d. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within a depth 1.25 m below the soil surface;
e. Do not have discernible fine or medium granular structure[6] or have only weak blocky or prismatic structure in the major part of the oxic horizon;
f. Have a hue redder than 10YR in all parts of the upper 75 cm that have a color value, moist, of 4 or more if the hue in horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron within the upper 75 cm;
g. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and is 60 cm or less above the horizon having the greater percentage of clay.

Tropeptic Eutrustox are like Typic Eutrustox except for *b* or *e*, or both.

Haplustox

Proposed distinctions between Typic Haplustox and other subgroups

Typic Haplustox are the Haplustox that
a. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the soil surface;
b. Have <5 percent plinthite by volume in all subhorizons within 1.25 m of the soil surface;
c. Have texture that is sandy clay loam or finer in all parts of the oxic horizon;

d. Have an oxic horizon that extends to a depth 1.25 m or more below the soil surface;
e. Do not have discernible fine or medium granular structure or have only weak blocky or prismatic structure[7] in the major part of the oxic horizon;
f. Have a hue redder than 10YR in all parts of the upper 75 cm that have a color value, moist, of 4 or more if the hue in horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron within the upper 75 cm; and
g. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and is 60 cm or less above the horizon having the greater percentage of clay.

Tropeptic Haplustox are like Typic Haplustox except for *d* or *e,* or both.

Ultic Haplustox are like Typic Haplustox except for *g* or for *e* and *g*.

Sombriustox

These are the Ustox that have a sombric horizon. They are not known to occur in the United States, including Puerto Rico, but they are reported in other countries. The classification of subgroups has not been developed.

[1] Some oxic horizons do not disperse well. The percentage of clay is determined by the higher value of (1) the measured percentage of clay or (2) 2.5 times the percentage of water retained at tension of 15 bars if the ratio of 15-bar water to measured clay is 0.6 or more.

[2] Structure in the macro sense. These soils normally have a strong but extremely fine granular structure that can be seen under a hand lens or in thin sections under a microscope. The individual granules are too fine to be seen with the naked eye.

[3] See footnote 2 above.

[4] See footnote 2 above.

[5] See footnote 1 above.

[6] See footnote 2 above.

[7] See footnote 2 above.

Chapter 12
Spodosols

Key to suborders

BA. Spodosols that either have an aquic moisture regime[1] or are artificially drained and have characteristics associated with wetness, namely one or more of the following:

1. A histic epipedon;

2. Mottling in an albic horizon or in the upper part of the spodic horizon;

3. A duripan in the albic horizon;

4. If free iron and manganese are absent or if the color value, moist, is less than 4 in the upper part of the spodic horizon, either

- **a.** Have any color if there are no coatings of iron oxides on the individual grains of silt and sand in or immediately below the spodic horizon wherever the value, moist, is 4 or more; or
- **b.** Have fine or medium mottles of iron or manganese in the materials immediately below the spodic horizon;

5. A placic horizon that rests on a fragipan or on a spodic horizon or on an albic horizon that is underlain by a spodic horizon but is not in a spodic horizon.

Aquods, p. 213

BB. Other Spodosols that have a spodic horizon in which the ratio of free iron (by dithionite-citrate) to carbon (both elemental) is 6 or more in all subhorizons.

Ferrods, p. 217

BC. Other Spodosols that have a spodic horizon in which some subhorizon that is present in more than half of each pedon has a ratio of free iron to carbon of <0.2.

Humods, p. 217

BD. Other Spodosols.

Orthods, p. 219

AQUODS

Key to great groups

BAA. Aquods that have a fragipan below the spodic horizon but do not have a placic horizon above the fragipan.

Fragiaquods, p. 214

BAB. Other Aquods that do not have a placic horizon but have a cryic temperature regime.

Cryaquods, p. 214

BAC. Other Aquods that have a strongly cemented or indurated albic horizon that does not slake in water when a dry fragment is immersed.

Duraquods, p. 214

BAD. Other Aquods that have a placic horizon that rests on a spodic horizon or on a fragipan or on an albic horizon that rests on a spodic horizon.

Placaquods, p. 216

BAE. Other Aquods that have a mean annual soil temperature of 8°C or higher and mean summer and mean winter soil temperatures at a depth of 50 cm that differ by <5°C.

Tropaquods, p. 216

BAF. Other Aquods that have in >50 percent of each pedon a spodic horizon in which some subhorizon has a ratio of free iron (by dithionite-citrate) to carbon (both elemental) that is <0.2.

Haplaquods, p. 215

BAG. Other Aquods.

Sideraquods, p. 216

Cryaquods

Distinctions between Typic Cryaquods and other subgroups

Typic Cryaquods are the Cryaquods that

a. Do not have a lithic contact within 50 cm of the surface of the mineral soil;

b. Have a mean annual soil temperature higher than 0° C;

c. Have a ratio of free iron to carbon (elemental) of <0.2 in some subhorizon;

d. Do not have mottles above the spodic horizon that are due to segregation of iron;

e. Do not have an argillic horizon underlying the spodic horizon; and

f. Have a continuous spodic horizon that is 10 cm or more thick or that is very firm when moist.

Lithic Cryaquods are like Typic Cryaquods except for *a* or for *a* and *b*.

Pergelic Cryaquods are like Typic Cryaquods except for *b*.

Pergelic Sideric Cryaquods are like Typic Cryaquods except for *b* and *c* or for *b, c,* and *d.*

Sideric Cryaquods are like Typic Cryaquods except for *c* or for *c* and *d.*

Duraquods

Definition

Duraquods are the Aquods that have a duripan in the albic horizon and have a temperature regime warmer than that of Cryaquods.

Fragiaquods

Distinctions between Typic Fragiaquods and other subgroups

Typic Fragiaquods are the Fragiaquods that

a. Have a frigid or warmer temperature regime;

b. Do not have a histic epipedon;

c. Have <5 percent by volume of iron-cemented nodules 2.5 to 30 cm in diameter in any subhorizon of the spodic horizon;

d. Do not have a surface horizon >30 cm thick that meets all requirements of a plaggen epipedon except thickness;

e. Do not have an intermittent upper black subhorizon of the spodic horizon that has a ratio of free iron (elemental) to carbon that is <0.2; or if plowed and the Ap horizon rests directly on the spodic horizon, do not have tongues of such a subhorizon;

f. Do not have an argillic horizon.

Alfic Fragiaquods are like Typic Fragiaquods except for *f.*

Cryic Fragiaquods are like Typic Frgiaquods except for *a* or for *a* and *b.*

Haplaquods

Distinctions between Typic Haplaquods and other subgroups

Typic Haplaquods are the Haplaquods that

a. Have an umbric epipedon or one that would meet the requirements for an umbric epipedon if it were plowed to a depth of 25 to 30 cm;

b. Do not have an argillic horizon underlying the spodic horizon;

c. Do not have a sandy epipedon (loamy fine sand or coarser throughout) that is 75 cm or more thick;

d. Have a spodic horizon that has a weighted average of 0.6 percent or more organic carbon in the matrix of the upper 30 cm of the spodic horizon or have an upper subhorizon of the spodic horizon that

(1) Has 2.3 percent or more organic carbon in the upper 2 cm; and

(2) Is continuous or is present in more than 90 percent of each pedon;

e. Have <5 percent by volume of iron-cemented nodules 2.5 to 30 cm in diameter in any subhorizon of the spodic horizon;

f. Do not have a lithic contact within 50 cm of the mineral soil surface;

g. Do not have a surface horizon >30 cm thick that meets all requirements of a plaggen epipedon except thickness;

h. Do not have a histic epipedon; and

i. Do not have a placic horizon in or below the spodic horizon.

Aeric Haplaquods are like Typic Haplaquods except for *a*.

Alfic Haplaquods are like Typic Haplaquods except for *b*, with or without *a* or *d*, or both, and have an albic horizon that tongues into the argillic horizon or have either base saturation of 35 percent or more (by sum of cations) in some part of the argillic horizon or have a mean annual soil temperature lower than 8° C.

Alfic Arenic Haplaquods are like Typic Haplaquods except for *a*, *b*, and *c*, have base saturation of 35 percent or more (by sum of cations) in some part of the argillic horizon or have a mean annual soil temperature lower than 8° C and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Arenic Haplaquods are like Typic Haplaquods except for *a* and *c*, and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Entic Haplaquods are like Typic Haplaquods except for *a* and *d*.

Ferrudalfic Haplaquods are like Typic Haplaquods except for *b* and *e*, with or without *a* or *d*, or both.

Grossarenic Haplaquods are like Typic Haplaquods except for *a* and *c*, and the upper boundary of the spodic horizon is between 1.25 m and 2 m below the soil surface.

Lithic Haplaquods are like Typic Haplaquods except for *f*, with or without *a* or *d*, or both.

Placic Haplaquods are like Typic Haplaquods except for *i,* with or without *a* or *h,* or both.

Ultic Hapalquods are like Typic Haplaquods except for *b,* with or without *a,* have base saturation (by sum of cations) <35 percent throughout the argillic horizon, and have a mean annual soil temperature of 8°C or higher.

Placaquods

Definition

Placaquods are the Aquods that have a placic horizon that rests on a spodic horizon, on a fragipan, or on an albic horizon that is underlain by a fragipan. There may be a histic epipedon at the surface. The horizons above the placic horizon are saturated with water at some period and have faint to distinct mottles of low chroma.

Sideraquods

Distinctions between Typic Sideraquods and other subgroups

Typic Sideraquods are the Sideraquods that

a. Have a spodic horizon that either

(1) Is at least very firm in some subhorizon when moist; or

(2) Is >10 cm thick and contains 1.2 percent or more organic carbon in the upper 10 cm;

b. Do not have a histic epipedon;

c. Do not have an argillic horizon.

Alfic Sideraquods are like Typic Sideraquods except for *c,* with or without *a,* and they have base saturation of 35 percent or more (by sum of cations) in some part of the argillic horizon or they have a mean annual soil temperature lower than 8°C.

Entic Sideraquods are like Typic Sideraquods except for *a.*

Tropaquods

Distinctions between Typic Tropaquods and other subgroups

Typic Tropaquods are the Tropaquods that

a. Do not have a histic epipedon;

b. Have <5 percent by volume of iron-cemented nodules, 2.5 to 30 cm in diameter, in any subhorizon of the spodic horizon;

c. Do not have an argillic horizon underlying the spodic horizon;

d. Do not have a lithic contact within 50 cm of the surface;

e. Have an umbric epipedon or one that would meet the requirements for an umbric epipedon if plowed to a depth of 25 to 30 cm;

f. Do not have a sandy epipedon (loamy fine sand or coarser throughout) that is 75 cm or more thick on the average for the thinnest half of the pedon;

g. Have a spodic horizon that has a weighted average of 0.6

percent or more organic carbon in the matrix of the upper 30 cm of the spodic horizon or have an upper subhorizon of the spodic horizon that

(1) Has 2.3 percent or more organic carbon in the upper 2 cm; and

(2) Is continuous or is present in >90 percent of each pedon; and

h. Have in 50 percent or more of each pedon a spodic horizon in which some subhorizon has a ratio of free iron (by dithionite-citrate) to carbon (both elemental) of <0.2.

Aeric Tropaquods are like Typic Tropaquods except for *e*.

Aeric Arenic Tropaquods are like Typic Tropaquods except for *e* and *f*, and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Aeric Grossarenic Tropaquods are like Typic Tropaquods except for *e* and *f*, and the upper boundary of the spodic horizon is between 1.25 m and 2 m below the soil surface.

Entic Tropaquods are like Typic Tropaquods except for *g*.

Histic Tropaquods are like Typic Tropaquods except for *a*.

Histic Lithic Tropaquods are like Typic Tropaquods except for *a* and *d*.

Ultic Tropaquods are like Typic Tropaquods except for *c*, with or without *e*.

FERRODS

This suborder is provisional. Ferrods are not known to occur in the United States, but the suborder is provided for use elsewhere. The classification has not been developed.

Ferrods are the Spodosols that

1. Have a spodic horizon that has in all subhorizons a ratio of percentage of free iron (by dithionite-citrate) to percentage of carbon (both elemental) of 6 or more; and

2. Do not have an aquic moisture regime or artificial drainage or do not have the characteristics associated with wetness as defined for Aquods.

HUMODS

Key to great groups

BCA. Humods that have a placic horizon in the spodic horizon.

Placohumods, p. 219

BCB. Other Humods that have an isomesic or warmer iso temperature regime.

Tropohumods, p. 219

BCC. Other Humods that have a fragipan below the spodic horizon.

Fragihumods, p. 218

BCD. Other Humods that have a cryic temperature regime.

Cryohumods, p. 218

BCE. Other Humods.

Haplohumods, p. 218

Cryohumods

Distinctions between Typic Cryohumods and other subgroups

Typic Cryohumods are the Humods that

a. Have 6 percent or more organic carbon (weighted average) in the matrix of the upper 30 cm of the spodic horizon or, if the spodic horizon is <30 cm thick, in the 30 cm directly below the top of the spodic horizon;

b. Do not have a lithic contact within 50 cm of the mineral soil surface;

c. Do not have an intermittent placic horizon in the spodic horizon;

d. Do not have an argillic horizon below the spodic horizon;

e. Have a mean annual soil temperature higher than 0° C.

Haplic Cryohumods are like Typic Cryohumods except for *a*.

Lithic Cryohumods are like Typic Cryohumods except for *b*, with or without *a* or *e*, or both.

Pergelic Cryohumods are like Typic Cryohumods except for *e* or for *a* and *e*.

Fragihumods

These are the Humods that have a fragipan below the spodic horizon and do not have a placic horizon. They are not known to occur in the United States, and the classification of subgroups has not been developed.

Haplohumods

Distinctions between Typic Haplohumods and other subgroups

Typic Haplohumods are the Haplohumods that

a. Have either

(1) A spodic horizon that has a weighted average of 0.6 percent or more organic carbon in the matrix of the upper 30 cm of the spodic horizon or below any Ap horizon; or

(2) A black upper subhorizon of the spodic horizon that has 3 percent or more organic carbon in the upper 2 cm and that is continuous or is present in >90 percent of the area of each pedon;

b. Have <5 percent by volume of iron-cemented nodules, 2.5 to 30 cm in diameter, in any subhorizon of the spodic horizon;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Do not have an argillic horizon below the spodic horizon;

e. Do not have a surface horizon >30 cm thick that meets all the requirements for a plaggen epipedon except thickness;

f. Have a udic moisture regime; and

g. Do not have a sandy epipedon (loamy fine sand or

coarser throughout) that is 75 cm or more thick.

Arenic Haplohumods are like Typic Haplohumods except for *g*, and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Arenic Ultic Haplohumods are like Typic Haplohumods except for *g* and *d*, with or without *a*, and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Entic Haplohumods are like Typic Haplohumods except for *a* or for *a* and *g*, and the upper boundary of the spodic horizon is within 1.25 m of the soil surface.

Ferrudalfic Haplohumods are like Typic Haplohumods except for *b*.

Grossarenic Entic Haplohumods are like Typic Haplohumods except for *a* and *g*, and the upper boundary of the spodic horizon is between 1.25 m and 2 m below the soil surface.

Lithic Haplohumods are like Typic Haplohumods except for *c*.

Orthic Haplohumods are like Typic Haplohumods except for *a(2)*, and the subhorizon is present in <90 percent of the pedon.

Plaggeptic Haplohumods are like Typic Haplohumods except for *e*.

Ultic Haplohumods are like Typic Haplohumods except for *d* or for *a* and *d*.

Xeric Haplohumods are like Typic Haplohumods except for *f*, and they have a xeric moisture regime.

Placohumods

Distinctions between Typic Placohumods and other subgroups

Typic Placohumods are the Placohumods that

a. Have a frigid or warmer temperature regime.

Cryic Placohumods are like the Typic Placohumods in defined properties except for *a*. They have, however, more organic carbon than Typic Placohumods, and in that way they resemble Cryohumods.

Tropohumods

Definition

Tropohumods are the Humods that have an isomesic or a warmer iso temperature regime.

ORTHODS

Key to great groups

BDA. Orthods that have a placic horizon in the spodic horizon.

Placorthods, p. 222

BDB. Other Orthods that have a fragipan below the spodic horizon.

Fragiorthods, p. 220

BDC. Other Orthods that have a cryic or pergelic temperature regime.

Cryorthods, p. 220

BDD. Other Orthods that have an isomesic or warmer iso temperature regime.

Troporthods, p. 222

BDE. Other Orthods.

Haplorthods, p. 221

Cryorthods

Distinctions between Typic Cryorthods and other subgroups

Typic Cryorthods are the Cryorthods that

a. Do not have an argillic horizon below the spodic horizon;

b. Have a cemented or indurated spodic horizon or have 1.2 to 6 percent organic carbon in the upper 10 cm of the spodic horizon;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a mean annual soil temperature higher than 0° C.

Boralfic Cryorthods are like Typic Cryorthods except for *a* or for *a* and *b*.

Entic Cryorthods are like Typic Cryorthods except for *b* in that they contain less than 1.2 percent organic carbon in the upper 10 cm of the spodic horizon.

Humic Cryorthods are like Typic Cryorthods except for *b* in that they contain >6 percent organic carbon in the upper 10 cm of the spodic horizon.

Humic Lithic Cryorthods are like Typic Cryorthods except for *c* and *b* and they contain >6 percent organic carbon in the upper 10 cm of the spodic horizon.

Lithic Cryorthods are like Typic Cryorthods except for *c* or for *c* and *d*.

Pergelic Cryorthods are like Typic Cryorthods except for *d*.

Fragiorthods

Distinctions between Typic Fragiorthods and other subgroups

Typic Fragiorthods are the Fragiorthods that

a. Do not have an argillic horizon below the spodic horizon;

b. Do not have distinct or prominent mottles in the spodic horizon;

c. Have a spodic horizon that has one or more of the following:

(1) A continuous horizon that is at least 2.5 cm thick and is very firm or extremely firm when moist (ortstein);

(2) A texture of very fine sand or finer and is more than 10 cm thick and has at least 1.2 percent organic carbon (weighted average) in the upper 10 cm;

(3) A coarse-loamy, loamy-skeletal, sandy-skeletal, or sandy particle-size class and has color value and chroma of 3 or less in at least the upper 7.5 cm;

d. Have a temperature regime warmer than that of Cryorthods;.

e. Do not have an intermittent upper black subhorizon of the spodic horizon that has a ratio of free iron (elemental) to carbon that is <0.2; or, if plowed and the Ap horizon rests directly on the spodic horizon, do not have tongues of such a subhorizon;
f. If plowed and the upper part of the spodic horizon thus is mixed in the Ap horizon and the soil does not have a continuous albic horizon, have more than 1.2 percent organic carbon in the Ap horizon; and
g. Do not have a surface horizon >30 cm thick that meets all the requirements for a plaggen epipedon except thickness.

Alfic Fragiorthods are like Typic Fragiorthods except for *a*, with or without *c* or *f*, or both, and have base saturation of 35 percent or more in some part of the argillic horizon or have a mean annual soil temperature less than 8° C.

Aquentic Fragiorthods are like Typic Fraiorthods exept for *b* and *c* or for *b, c,* and *f.*

Aquic Fragiorthods are like Typic Fragiorthods except for *b.*

Cryic Fragiorthods are like Typic Fragiorthods except for *d.*

Entic Fragiorthods are like Typic Fragiorthods except for *c.*

Humic Fragiorthods are like Typic Fraiorthods except for *e.*

Plaggeptic Fragiorthods are like Typic Fragiorthods except for *g.*

Haplorthods

Distinctions between Typic Haplorthods and other subgroups

Typic Haplorthods are the Haplorthods that
a. Do not have an argillic horizon below the spodic horizon;
b. Have a spodic horizon that has one or more of the following:

(1) A continuous horizon at least 2.5 cm thick that is very firm or extremely firm when moist (ortstein);
(2) A texture of very fine sand or finer and is more than 10 cm thick and has a weighted average of at least 1.2 percent organic carbon in the upper 10 cm; or
(3) A coarse-loamy, loamy-skeletal, sandy-skeletal, or sandy particle-size class and color value and chroma, moist, of 3 or less in at least the upper 7.5 cm of the spodic horizon;

c. Do not have distinct or prominent mottles of approximate spherical shape in the spodic horizon unless the variability in color is associated with differences in consistence in such a manner that the redder or darker parts are extremely firm or very firm, or, if the color is due to uncoated sand grains, do not have the water table within 1 m of the soil surface for as many as 60 days, cumulative, in most years;
d. Do not have chroma of 2 or less if mottled or chroma

less than 2 if not mottled, that is dominant in the matrix within 15 cm below the base of the spodic horizon and within 1 m of the surface of the soil;
e. Do not have a horizon 15 cm or more thick below the spodic horizon and within 1 m of the surface that has a brittle matrix when wet or contains some durinodes;
f. Do not have a lithic contact within 50 cm of the surface;
g. Do not have a black intermittent upper subhorizon that has a ratio of free iron (elemental) to carbon that is <0.2;
h. Have <6 percent organic carbon in the upper 10 cm of the spodic horizon;
i. Have 1.2 percent or more organic carbon in the Ap horizon if the Ap horizon extends into the upper part of the spodic horizon.

Alfic Haplorthods are like Typic Haplorthods except for *a* or for *a* and *b*, with or without *i*, and the argillic horizon either has base saturation of 35 percent or more in some part or has a mean annual soil temperature lower than 8° C.

Aqualfic Haplorthods are like Typic Haplorthods except for *a* and *c*, *a* and *d*, or *a,c* and *d*, and the argillic horizon either has base saturation of 35 percent or more in some part or has a mean annual soil temperature lower than 8° C.

Aquentic Haplorthods are like Typic Haplorthods except for *b* and *c* with or without *d*.

Aquic Haplorthods are like Typic Haplorthods except for *c* or *d* or for both *c* and *d*.

Duric Haplorthods are like Typic Haplorthods except for *e* or for *c* and *e*.

Entic Haplorthods are like Typic Haplorthods except for *b*, with or without *i*.

Entic Lithic Haplorthods are like Typic Haplorthods except for *f* and *b*, with or without *i*.

Humic Haplorthods are like Typic Haplorthods except for *g* or *h*.

Lithic Haplorthods are like Typic Haplorthods except for *f*.

Ultic Haplorthods are like Typic Haplorthods except for *a* or for *a* and *b*, with or without *i*, and the argillic horizon has base saturation throughout of <35 percent and has a mean annual soil temperature of 8° C or more.

Placorthods

These are the orthods that have a placic horizon in the spodic horizon. They are not known to occur in the United States, and they are thought to be rare elsewhere in the world. Subgroups have not been defined.

Troporthods

These are the Orthods that have an isomesic or warmer iso temperature regime. They are not known to occur in the United States, but the group is provided for use elsewhere. Subgroups have not been defined.

[1] If a placic horizon, duripan, or fragipan is present, the soil need not be saturated below that horizon.

Chapter 13
Ultisols

Key to suborders

FA. Ultisols, either saturated with water at some time of year or artificially drained, that have characteristics associated with wetness, namely, mottles, iron-manganese concretions >2 mm in diameter, or chroma, moist, of 2 or less immediately below any Ap or A1 horizon that has a value, moist, of less than 3.5 when rubbed; and also one or more of the following:

1. Dominant chroma, moist, of 2 or less in coatings on the surface of peds and mottles within the peds, or dominant chroma of 2 or less in the matrix of the argillic horizon and mottles of higher chroma (if the hue is redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived);

2. Chroma, moist, of 1 or less on surfaces of peds or in the matrix of the argillic horizon; or

3. Dominant hue of 2.5Y or 5Y in the matrix of the argillic horizon and distinct or prominent mottles and also a thermic or isothermic or warmer soil temperature regime.

Aquults, p. 223

FB. Other Ultisols that have either or both of the following characteristics:

1. Have 0.9 percent or more organic carbon in the upper 15 cm of the argillic horizon; or

2. Have 12 kg or more organic carbon in the soil per square meter to a depth of 1 m below the base of the mineral soil surface, exclusive of any O horizon that may be present.

Humults, p. 226

FC. Other Ultisols that have a udic moisture regime.

Udults, p. 230

FD. Other Ultisols that have an ustic moisture regime.

Ustults, p. 235

FE. Other Ultisols that have a xeric moisture regime.

Xerults, p. 238

AQUULTS

Key to great groups

FAA. Aquults that have plinthite that forms a continuous phase or constitutes more than half the matrix of some subhorizon within 1.25 m of the soil surface.

Plinthaquults, p. 225

FAB. Other Aquults that have a fragipan and, if there is 5 percent or more by volume of plinthite in some subhorizon, the upper boundary of the fragipan is within 1 m of the surface of the soil.

Fragiaquults, p. 224

FAC. Other Aquults that have an abrupt textural change between the ochric epipedon or the albic horizon and the argillic horizon and have slow hydraulic conductivity in the argillic horizon.

Albaquults, p. 224

FAD. Other Aquults that have a clay distribution such that the percentage of clay does not decrease from its maximum by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface, or the horizon in which the percentage of clay is less than the maximum has skeletans on ped faces or contains 5 percent or more plinthite by volume; and the upper 50 cm of the argillic horizon has <10 percent weatherable minerals in the 20- to 200-micron fraction.

Paleaquults, p. 225

ULT

FAE. Other Aquults that have an isomesic or warmer iso temperature regime.

Tropaquults, p. 225

FAF. Other Aquults that have an ochric epipedon.

Ochraquults, p. 224

FAG. Other Aquults that have an umbric or a mollic epipedon.

Umbraquults, p. 226

Albaquults

Typic Albaquults.—These are the Albaquults that have the colors definitive for the suborder in 60 percent or more of the matrix between the A1 or Ap horizon and a depth of 75 cm. They are moderately extensive in the United States on parts of the coastal plains in the southeastern states.

Aeric Albaquults.—These soils are not known to occur in significant areas in the United States, but the subgroup is provided for use if needed. Either they have the colors that are definitive for the suborder on ped faces but not in the ped interiors or they have an ochric epipedon that has higher chroma or a redder hue, or both.

Fragiaquults

Distinctions between Typic Fragiaquults and other subgroups

Typic Fragiaquults are the Fragiaquults that

a. Have an ochric epipedon;

b. Have mottles and have dominant chroma of 2 or less in all horizons between the A1 or Ap horizon and the fragipan; and

c. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m of the soil surface.

Aeric Fragiquults are like Typic Fragiquults except for *b.*

Plinthic Fragiaquults are like Typic Fragiaqullts except for *c* and have lenticular platy structure in the fragipan.

Plinthudic Fragiaquults are like Typic Fragiaquults except for *b* and *c* and have lenticular platy structure in the fragipan.

Ochraquults

Description of subgroups

Typic Ochraquults.—These are the Ochraquults that have the colors definitive for Aquults in 60 percent or more of the matrix between the A1 or Ap horizon and a depth of 75 cm. These soils in the United States are mainly on the Atlantic Coastal Plain. Most of them have a mesic or thermic soil temperature regime.

Aeric Ochraquults.—Soils in this subgroup have the colors definitive for Aquults on ped faces but not in the ped interiors, or they have a subhorizon in the ochric epipedon that has chroma of 3 or more in a hue of 10YR or redder, or both. They are mainly in the Middle Atlantic and southern states in the United States, but they are not extensive. Many have been cleared and drained and are being cultivated or used for pasture.

Paleaquults

Distinctions between Typic Paleaquults and other subgroups

Typic Paleaqullts are the Paleaquults that
a. Do not have a horizon that has dominant chroma of 3 or more within 75 cm of the soil surface;
b. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;
c. Have <5 percent plinthite (by volume) in all horizons within 1.5 m of the soil surface; and
d. Have an ochric epipedon.

Aeric Paleaquults are like Typic Paleaquults except for *a.*

Arenic Paleaquults are like Typic Paleaquults except for *b,* and they have a sandy particle-size class to a depth between 50 cm and 1 m.

Arenic Plinthic Paleaquults are like Typic Paleaquults except for *b* and *c,* and they have a sandy particle-size class to a depth between 50 cm and 1 m.

Arenic Umbric Paleaquults are like Typic Paleaquults except for *b* and *d,* and they have a sandy particle-size class to a depth between 50 cm and 1 m.

Grossarenic Paleaquults are like Typic Paleaquults except for *b,* and they have a sandy particle-size class to a depth of ≥1 m in half or more of the pedon.

Plinthic Paleaqullts are like Typic Paleaquults except for *c.*

Umbric Paleaquults are like Typic Paleaquults except for *d.*

Plinthaquults

Distinction between Typic and Oxic Plinthaquults

The distinction between the typic and oxic subgroups that follows is incomplete and provisional.

Typic Plinthaquults are the Plinthaquults that have CEC of >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1N NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon. Cation-retention capacity is defined under the oxic horizon in chapter 1.

Oxic Plinthaquults are like Typic Plinthaquults but have CEC of <24 meq per 100 g clay and cation-retention capacity of <12 meq per 100 g clay.

Tropaquults

Provisional distinctions between Typic Tropaquults and other subgroups

Typic Tropaquults are the Tropaquults that
a. Have an A1 horizon that is <15 cm thick if its color value, moist, is darker than 3.5 or have an Ap horizon that has a color value, moist, of 4 or more;
b. Do not have a subhorizon that has dominant chroma of 3 or more within 75 cm of the soil surface; and

c. Do not have plinthite that constitutes 5 percent or more of the matrix of any subhorizon within 1.5 m of the soil surface.

Aeric Umbric Tropaquults are like Typic Tropaquults except for *a* and *b*.

Plinthic Tropaquults are like Typic Tropaquults except for *c*.

Umbric Tropaquults are like Typic Tropaquults except for *a*.

Umbraquults

Definition

Umbraquults are the Aquults that

1. Have an umbric or mollic epipedon;

2. Do not have a fragipan;

3. Do not have plinthite that forms a continuous phase or constitutes more than half of the matrix of any subhorizon within 1.25 m of the soil surface;

4. Have mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C or more; and

5. Have one or both of the following characteristics:

> **a.** Clay distribution such that the percentage of clay decreases from its maximum by 20 percent or more of that maximum within a depth of 1.5 m from the soil surface, and the horizon in which the clay content is less than the maximum has <5 percent plinthite by volume and few or no skeletans; or
>
> **b.** Ten percent or more weatherable minerals in the 20-to 200-micron fraction in the upper 50 cm of the argillic horizon.

HUMULTS

Key to great groups

FBA. Humults that have a sombric horizon within 1 m of the soil surface.

Sombrihumults, p. 228

FBB. Other Humults that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in the upper 50 cm and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum shows skeletans on ped faces or has 5 percent or more plinthite by volume.

Palehumults, p. 227

FBC. Other Humults that have plinthite that forms a continuous phase or constitutes >50 percent of the volume of some subhorizon within 1.25 m of the soil surface.

Plinthohumults, p. 228

FBD. Other Humults that have mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or a paralithic contact, whichever is shallower, that differ by <5°C.

Tropohumults, p. 228

FBE. Other Humults.

Haplohumults, p. 227

Haplohumults

Distinctions between Typic Haplohumults and other subgroups

Typic Haplohumults are the Haplohumults that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g or less per cubic centimeter in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Have a udic moisture regime;

c. Do not have the following combination of characteristics in the upper 25 cm or more of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less accompanied by mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C or more or artificial drainage; and

d. Do not have a lithic contact within 50 cm of the mineral soil surface.

Andeptic Haplohumults are like Typic Haplohumults except for *a*.

Aquic Haplohumults are like Typic Haplohumults except for *c*.

Xeric Haplohumults are like Typic Haplohumults except for *b* and have a xeric soil moisture regime.

Palehumults

Distinctions between Typic Palehumults and other subgroups

Typic Palehumults are the Palehumults that

a. Have >24 meq CEC per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1N NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon;

b. Do not have the following combination of characteristics in the upper 25 cm or more of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more, and chroma, moist, of 2 of less accompanied by mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C or more or artificial drainage;

c. Have a udic moisture regime;

d. Do not have a layer in the upper 75 cm that has texture finer than loamy fine same, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g

ULT

per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

e. Have <5 percent plinthite (by volume) in all horizons within 1.5 m of the soil surface; and

f. Have, in all parts of the soil above a depth of 75 cm, a hue redder than 10YR and a color value, moist, of 4 or more if there are mottles of high chroma within this depth and if the hue becomes redder with depth within 1 m of the soil surface.

Epiaquic Palehumults are like Typic Palehumults except for *f.*

Orthoxic Palehumults are like Typic Palehumults except for *a.*

Plinthic Palehumults are like Typic Palehumults except for *e.*

Ustic Palehumults are like Typic Palehumults except for *c* and have an ustic moisture regime.

Xeric Palehumults are like Typic Palehumults except for *c* and have a xeric moisture regime.

Plinthohumults

These are the Humults that have plinthite that forms a continuous phase or that constitutes more than half the volume of some subhorizon within 1.25 m of the soil surface. They are not known to occur in the United States, but the great group has been proposed for other countries (Sys 1969). Subgroups have not been developed.

Sombrihumults

These are the Humults that have a sombric horizon whose upper boundary is within 1 m of the soil surface. They are not known to occur in the United States, but the great group is proprovided for use elsewhere. Humoxic and orthoxic subgroups have been proposed (Sys 1969) for the soils that have low CEC, that is, <24 meq per 100 g clay. The humoxic subgroup is proposed for soils that have an isothermic or cooler temperature regime and the orthoxic subgroup for soils that have an isohyperthermic temperature regime.

Tropohumults

Distinctions between Typic Tropohumults and other subgroups

Typic Tropohumults are the Tropohumults that

a. Have CEC of >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1N NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon;

b. Do not have the following combination of characteristics within 75 cm of the soil surface:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less and also mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C or higher or there is artificial drainage;

c. Do not have a lithic contact within 50 cm of the mineral soil surface;

d. Do not have interruptions of the argillic horizon by ledges of bedrock within each pedon;

e. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

f. Have a udic moisture regime;

g. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

h. Have a hue redder than 10YR in all parts of the soil above a depth of 75 cm that have a color value, moist, of 4 or more if there are mottles of high chroma above that depth and if the hue becomes redder with depth within 1 m of the soil surface; and

i. Do not have an anthropic epipedon.

Anthropic Tropohumults are like Typic Tropohumults except for *i.*

Aquic Tropohumults are like Typic Tropohumults except for *b* or for *b* and *h.*

Arenic Tropohumults are like Typic Tropohumults except for *e.* They have a sandy epipedon that is 50 cm to 1 m thick, and the upper boundary of the argillic horizon is within 1 m of the soil surface.

Eqiaquic Tropohumults are like Typic Tropohumults except for *h.*

Epiaquic Orthoxic Tropohumults are like Typic Topohumults except for *a* and *h,* and the soils are dry in some horizon in the moisture control section in most years but are not dry for 60 consecutive days or more.

Humoxic Tropohumults are like Typic Tropohumults except for *a,* and the soils are never dry in any part of the moisture control section in most years.

Orthoxic Tropohumults are like Typic Tropohumults except for *a,* and the soils are dry in some horizon in the moisture control section in most years but are not dry for 60 consecutive days or more.

Ustic Tropohumults are like Typic Tropohumults except for *f* and have an ustic moisture regime.

Ustoxic Tropohumults are like Typic Tropohumults except for *a* and *f* and have an ustic moisture regime.

UDULTS

Key to great groups

FCA. Udults that have a fragipan in or below the argillic horizon.

Fragiudults, p. 230

FCB. Other Udults that have plinthite that forms a continuous phase or constitutes more than half the volume in some horizon within the upper 1.25 m of the soil.

Plinthudults, p. 234

FCC. Other Udults that do not have a lithic or a paralithic contact within 1.5 m of the mineral soil surface and that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in the upper 50 cm and have a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans on ped faces or has 5 percent or more plinthite by volume.

Paleudults, p. 232

FCD. Other Udults that have

1. An epipedon that has a color value, moist, of less than 4 in all parts; and

2. An argillic horizon that has a color value, dry, of less than 5 and not more than 1 unit higher than the value, moist.

Rhodudults, p. 234

FCE. Other Udults that have an isomesic or warmer iso temperature regime.

Tropudults, p. 234

FCF. Other Udults.

Hapludults, p. 231

Fragiudults

Distinctions between Typic Fragiudults and other subgroups

Typic Fragiudults are the Fragiudults that

a. Meet these two requirements:

(1) Have an argillic horizon above the fragipan that has some clay skins on both vertical and horizontal surfaces of some structural aggregates; and

(2) Do not have an intervening horizon (one or more) between the argillic horizon and the fragipan that has dominant chroma of 3 or less and that has as much as 3 percent less clay (absolute) than both the overlying argillic horizon and the underlying fragipan;

b. Do not have the following combination of characteristics in the upper 25 cm of the argillic horizon and within 40 cm of the soil surface:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less accompanied by mottles of higher chroma that are due to segregation of iron; and

(2) Are saturated with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C or higher or are artificially drained;

c. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

d. Have <5 percent plinthite by volume in all horizons within 1.5 m of the soil surface; and

e. Have an Ap horizon that has a color value, moist, of 4 or

more or has a value, dry, of 6 or more when crushed and smoothed (smoothed with a knife to eliminate shadows), or the A1 horizon is <15 cm thick if its color value, moist, is lower than 3.5.

Aquic Fragiudults are like Typic Fragiudults except for *b.*

Arenic Fragiudults are like Typic Fragiudults except for *c* or for *a* and *c,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Glossaquic Fragiudults are like Typic Fragiudults except for *a* and *b,* and they have a horizon or horizons, including any Ap horizon, above the fragipan that (1) have dominant chroma of 3 or more; (2) have mottles that have chroma, moist, of 2 or less within 40 cm of the soil surface; and (3) have mottles of higher chroma or redder hue because of the segregation of iron.

Glossic Fragiudults are like Typic Fragiudults except for *a* and they have a horizon or horizons, including any Ap, above the fragipan that (1) are 25 cm or more thick, (2) have chroma of 3 or more in the matrix, and (3) if clay skins are present, do not have mottles that have chroma of 2 or less within 40 cm of the soil surface and also do not have mottles of higher chroma or redder hue that are due to the segregation of iron.

Plinthaquic Fragiudults are like Typic Fragiudults except for *a, b,* and *d,* have lenticular platy structure in the frgipan, and have between the A1 or Ap horizon and the fragipan a horizon or horizons that (1) have dominant chroma of 3 or more in the matrix and (2) have mottles that have chroma of 2 or less within 40 cm of the soil surface.

Plinthic Fragiudults are like Typic Fragiudults except for *a* and *d,* have lenticular platy structure in the fragipan, and have between the soil surface and the fragipan a horizon or horizons that (1) have dominant chroma of 3 or more in the matrix and (2) do not have mottles that have chroma of 2 or less within 40 cm of the soil surface accompanied by mottles that have high chroma and reddish hue and are due to the segregation of iron.

Hapludults

Distinctions between Typic Hapludults and other subgroups

Typic Hapludults are the Hapludults that

a. Do not have the following combination of characteristics in the upper 60 cm of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less, and also mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C or higher, or artificial drainage;

b. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

c. Have an argillic horizon >25 cm thick;

d. Have an Ap horizon that has a color value, moist, of 4

or more or has a value, dry, of 6 or more when crushed and smoothed; or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5;

e. Do not have a lithic contact within 50 cm of the surface of the mineral soil;

f. Have texture finer than loamy fine sand in some part of the argillic horizon and have an argillic horizon that, in at least its upper 25 cm, does not have lamellae;

g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface, to the base of an Ap horizon, or to a depth within 25 cm of the soil surface; and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

h. Have a continuous argillic horizon throughout each pedon, not interrupted by ledges of bedrock.

Aquic Hapludults are like Typic Hapludults except for *a* or for *a* and *d*.

Arenic Hapludults are like Typic Hapludults except for *b*, with or without *a* or *c* or both, and the epipedon is between 50 cm and 1 m thick.

Humic Hapludults are like Typic Hapludults except for *d*.

Lithic Hapludults are like Typic Hapludults except for *e* or for *c* and *e*.

Ochreptic Hapludults are like Typic Hapludults except for *c*.

Psammentic Hapludults are like Typic Hapludults except for *f* or for *f* and *b*.

Ruptic-Lithic-Entic Hapludults are like Typic Hapludults except for *h* and *e* or for *h,c,* and *e*.

Vertic Hapludults are like Typic Hapludults except for *g*, with or without *a*.

Paleudults

Distinctions between Typic Paleudults and other subgroups

Typic Paleudults are the Paleudults that

a. Do not have the following combination of characteristics in the upper 75 cm of the soil if the chroma throughout the upper 75 cm is not controlled by the uncoated sand grains; or if the chroma throughout the upper 75 cm is controlled by uncoated sand grains, do not have the following combination of characteristics throughout the upper 12.5 cm of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more

(1) ... and chroma, moist, of 2 or less and mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5°C higher, or artificial drainage;

b. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

c. Do not have a subhorizon within 1.5 m of the soil surface that has >5 percent plinthite;

d. Have an argillic horizon that has a color value, moist, of 4 or more or that has mottles of high chroma in some subhorizon within 1 m of the top of the argillic horizon, or have a color value, dry, more than 1 unit higher than the value, moist, in some part of the soil within that depth;

e. Have texture finer than loamy fine sand in some part of the argillic horizon and do not have lamellae in at least the upper 1 m of the argillic horizon;

f. Do not have a horizon that is above the argillic horizon whose lower boundary is deeper than 18 cm and that meets all requirements for a spodic horizon except the horizon is intermittent; and

g. Do not have a subhorizon in the argillic horizon and within 1.25 m of the soil surface that has all the properties of a fragipan except that it is brittle in 40 to 60 percent of the volume.

Aquic Paleudults are like Typic Paleudults except for *a.*

Aquic Arenic Paleudults are like Typic Paleudults except for *a* and *b,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Arenic Paleudults are like Typic Paleudults except for *b,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Arenic Plinthaquic Paleudults are like Typic Paleudults except for *a, b,* and *c,* with or without *g.* They have a sandy epipedon that is 50 cm to 1 m thick, and have mottles that have chroma of 2 or less and also have high-chroma mottles in the sandy epipedon and in the upper 12.5 cm of the argillic horizon.

Arenic Plinthic Paleudults are like Typic Paleudults except for *b* and *c* or for *b, c,* and *g,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Arenic Rhodic Paleudults are like Typic Paleudults except for *b* and *d,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Fragiaquic Paleudults are like Typic Paleudults except for *a* and *g* or for *a,c,* and *g.*

Fragic Paleudults are like Typic Paleudults except for *g* or for *c* and *g.*

Grossarenic Paleudults are like Typic Paleudults except for *b* or for *a* and *b,* and they have a sandy epipedon that is between 1 and 2 m thick in half or more of each pedon.

Grossarenic Plinthic Paleudults are like Typic Paleudults except for *b* and *c* or for *b, c,* and *g,* and they have a sandy epipedon that is between 1 and 2 m thick in half or more of each pedon.

Plinthaquic Paleudults are like Typic Paleudults except for *a* and *c.*

Plinthic Paleudults are like Typic Paleudults except for *c*.

Psammaquentic Paleudults are like Typic Paleudults except for *a* and *e*, with or without *b*.

Psammentic Paleudults are like Typic Paleudults except for *e*.

Rhodic Paleudults are like Typic Paleudults except for *d*.

Spodic Paleudults are like Typic Paleudults except for *f*, with or without *a* or *b*, or both.

Plinthudults

Definition

Plinthudults are the Udults that have plinthite that forms a continuous phase or constitutes more than half the matrix of some subhorizon in the upper 1.25 m of the soil.

Rhododults

Distinctions between Typic Rhodudults and other subgroups

Typic Rhodudults are the Rhodudults that

a. Have an argillic horizon that is continuous vertically and horizontally and has a hue redder than 5YR;

b. Have texture finer than loamy fine sand in some part of the argillic horizon; and

c. Do not have a lithic contact within 50 cm of the soil surface.

Tropudults

Distinctions between Typic Tropudults and other subgroups

Typic Tropudults are the Tropudults that

a. Do not have the following combination of characteristics in the upper 75 cm of the soil and in the upper 12.5 cm of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less and mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year or the soil is artificially drained;

b. Do not have an epipedon as thick as 50 cm if its particle-size class is sandy throughout;

c. Have an argillic horizon that is >40 cm thick;

d. Have CEC >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon (cation-retention capacity is defined in ch. 1 under the oxic horizon);

e. Do not have a horizon that has >5 percent plinthite by volume within 1.5 m of the soil surface;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm

or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

g. Have texture finer than loamy fine sand in some part of the argillic horizon and have an argillic horizon that in at least its upper 25 cm does not have lamellae;

h. Have a continuous argillic horizon throughout each pedon, not interrupted by ledges of bedrock;

i. Do not have a lithic contact within 50 cm of the soil surface;

j. Have a hue redder than 10YR in all parts of the soil above a depth of 75 cm that have color value, moist, of 4 or more if there are mottles of high chroma within that depth and if the hue becomes redder with depth within 1 m of the soil surface; and

k. Do not have a petroferric contact within 1 m of the soil surface.

Aquic Tropudults are like Typic Tropudults except for *a.*

Arenic Orthoxic Tropudults are like Typic Tropudults except for *b* and *d,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Dystropeptic Tropudults are like Typic Tropudults except for *c.*

Epiaquic Tropudults are like Typic Tropudults except for *j.*

Orthoxic Tropudults are like Typic Tropudults except for *d.*

Petroferric Tropudults are like Typic Tropudults except for *k.*

Plinthaquic Tropudults are like Typic Tropudults except for *a* and *e.*

Plinthic Tropudults are like Typic Tropudults except for *e.*

Vertic Tropudults are like Typic Tropudults except for *f,* with or without *a* or *j,* or both.

USTULTS

Key to great groups

FDA. Ustults that have plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 1.25 m of the soil surface.

Plinthustults, p. 237

FDB. Other Ustults that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in its upper 50 cm and have a clay distribution with depth such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the

percentage of clay is less than the maximum has skeletans on ped faces or has 5 percent or more plinthite by volume.

Paleustults, p. 237

FDC. Other Ustults that have:

1. An epipedon that has a color value, moist, less than 4 in all parts; and

2. An argillic horizon that has a color value, dry, less than 5 and not more than 1 unit higher than the value, moist.

Rhodustults, p. 237

FDD. Other Ustults.

Haplustults, p. 236

Haplustults

Distinctions between Typic Haplustults and other subgroups

Typic Haplustults are the Haplustults that

a. Have a continuous argillic horizon throughout each pedon, uninterrupted by ledges of bedrock;

b. Do not have a lithic contact within 50 cm of the mineral soil surface;

c. Have texture finer than loamy fine sand in some part of the argillic horizon and have an argillic horizon that does not have lamellae in at least its upper 25 cm;

d. Do not have the following combination of characteristics in the upper 75 cm of the soil and in the upper 12.5 cm of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less and mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5° C or higher or artificial drainage;

e. Have a hue redder than 10YR in all parts of the upper 75 cm of soil that have a color value, moist, of 4 or more if there are mottles of high chroma within that depth and if the hue becomes redder with depth within 1 m of the soil surface;

f. Do not have a petroferric contact within 1 m of the soil surface;

g. Do not have a horizon within 1.5 m of the soil surface that has ≥ 5 percent plinthite by volume;

h. Have CEC >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon (cation-retention capacity is defined in ch. 1 under the oxic horizon); and

i. Do not have an epipedon as thick as 50 cm if its particle-size class is sandy throughout.

Aquic Haplustults are like Typic Haplustults except for *d.*

Arenic Haplustults are like Typic Haplustults except for *i,* and they have a sandy epipedon that is 50 cm to 1 m thick.

Epiaquic Haplustults are like Typic Haplustults except for *e.*

Lithic Haplustults are like Typic Haplustults except for *b.*

Oxic Haplustults are like Typic Haplustults except for *h*.

Petroferric Haplustults are like Typic Haplustults except for *f*.

Plinthic Haplustults are like Typic Haplustults except for *g*.

Paleustults

Definition

Paleustults are the Ustults that

1. Have both the following characteristics:

a. An argillic horizon that in its upper 50 cm has <10 percent weatherable minerals in the 20- to 200-micron fraction; and

b. A clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans or other evidences of clay eluviation or has 5 percent or more plinthite.

2. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 1.25 m of the soil surface; and

3. Do not have a fragipan.

Plinthustults

Definition

Plinthustults are the Ustults that have plinthite that forms a continuous phase or constitutes more than half the matrix within some subhorizon in the upper 1.25 m of the soil.

Rhodustults

Definition

Rhodustults are the Ustults that do not have a fragipan and also

1. Have an epipedon that has a color value, moist, less than 4 in all parts;

2. Have an argillic horizon that has a color value, dry, less than 5 in all subhorizons and not more than 1 unit higher than the value, moist;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon in the upper 1.25 m of the soil; and

4. Have either or both of the following characteristics:

a. Clay distribution with depth such that the percentage of clay decreases from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, and the layer in which the percentage of clay is less than the maximum does not have evidences of clay eluviation in the form of skeletans on ped surfaces or has 5 percent or more plinthite by volume; or

b. An argillic horizon that has 10 percent or more weatherable minerals in the 20- to 200-micron fraction of its upper 50 cm.

XERULTS

Key to great groups

FEA. Xerults that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in its upper 50 cm and have a clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans on ped faces or has 5 percent or more plinthite by volume.

Palexerults, p. 239

FEB. Other Xerults.

Haploxerults, p. 238

Haploxerults

Distinctions between Typic Haploxerults and other subgroups

Typic Haploxerults are the Haploxerults that

a. Do not have the following combination of characteristics in the upper 25 cm or more of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less and also mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5° C or higher, or the soil is artificially drained;

b. Do not have a lithic contact within 50 cm of the mineral soil surface;

c. Have texture finer than loamy fine sand in some part of the argillic horizon and have an argillic horizon that does not have lamellae in at least its upper 25 cm;

d. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

e. Have a continuous argillic horizon throughout each pedon, not interrupted by ledges of bedrock; and

f. Do not have an epipedon as thick as 50 cm if its particle-size class is sandy throughout.

Ruptic-Lithic-Xerochreptic Haploxerults are like Typic Haploxerults except for *b* and *e*.

Palexerults

Definition

Palexerults are the Xerults that

1. Have both the following characteristics:

    a. An argillic horizon that in its upper 50 cm has <10 percent weatherable minerals in the 20- to 200-micron fraction; and

    b. A clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans on ped faces or has 5 percent or more plinthite by volume;

2. Have a color value, moist, of 4 or more in some part of the epipedon or have an argillic horizon that has a color value, dry, of 5 or more in some subhorizon or a color value, moist, of 4 or more;

3. Do not have plinthite that forms a continuous phase or constitues more than half the matrix in any subhorizon within 1.25 m of the soil surface; and

4. Do not have a fragipan.

Chapter 14
Vertisols

Key to suborders

DA. Vertisols that have a thermic, mesic, or frigid soil temperature regime and, unless irrigated, have cracks that open and close once each year and remain open for 60 consecutive days or more in the 90 days following the summer solstice in more than 7 out of 10 years but that are closed for 60 consecutive days or more during the 90 days following the winter solstice.

Xererts, p. 243

DB. Other Vertisols that, unless irrigated, have in most years cracks that either remain open throughout the year or are closed for less than 60 consecutive days at a period when the soil temperature at a depth of 50 cm is continuously higher than 8°C.

Torrerts, p. 241

DC. Other Vertisols that have cracks that open and close one or more times during the year in most years but do not remain open for as many as 90 cumulative days in most years.

Uderts, p. 241

DD. Other Vertisols.

Usterts, p. 242

TORRERTS

Distinctions between Typic Torrerts and other subgroups

Typic Torrerts are the Torrerts that

a. Have a color value, moist, or 4 or more in the surface horizon in more than half of each pedon, or the upper horizon that has a color value (moist) less than 4 is <30 cm thick; and

b. Do not have prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix within 1 m of the soil surface.

Mollic Torrerts are like Typic Torrerts except for *a*.

Paleustollic Torrerts are like Typic Torrerts except for *a* and *b*.

UDERTS

Key to great groups

DCA. Uderts that have a chroma, moist, of 1.5 or more dominant in the matrix of some subhorizon in the upper 30 cm in more than half of each pedon.

Chromuderts, p. 241

DCB. Other Uderts.

Pelluderts, p. 242

Chromuderts

Distinctions between Typic Chromuderts and other subgroups

Typic Chromuderts are the Chromuderts that

a. Do not have distinct or prominent mottles within 50 cm of the soil surface in more than half of each pedon (the terms refer to contrast, not to size of the mottles); and

b. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon.

Aquentic Chromuderts are like Typic Chromuderts except for *a* and *b*.

Aquic Chromuderts are like Typic Chromuderts except for *a*.

Entic Chromuderts are like Typic Chromuderts except for *b*.

Pelluderts

Definition of Typic Pelluderts

Typic Pelluderts are the Pelluderts that have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon.

Description of subgroups

Typic Pelluderts.—The central concept or typic subgroup of Pelluderts is fixed on soils that have a thick, dark epipedon. The color of the surface layer and the content of organic matter are about the only visible properties that vary in the great group. Base saturation also varies. These soils are extensive locally on the Gulf Coast in Texas. They were fomerly cultivated, but most of them are now used for pasture.

Entic Pelluderts.—These soils are like Typic Pelluderts except for their color value. This is the only subgroup besides Typic Pelluderts that has been recognized in the United States. A surface horizon that has a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either is absent or is <30 cm thick in more than half of each pedon. These soils are not extensive in the United States. They are used mostly for pasture.

USTERTS

Key to great groups

DDA. Usterts that have a chroma, moist, of 1.5 or more in some part of the matrix of the upper 30 cm in more than half of each pedon.

Chromusterts, p. 242

DDB. Other Usterts.

Pellusterts, p. 243

Chromusterts

Distinctions between Typic Chromusterts and other subgroups

Typic Chromusterts are the Chromusterts that

a. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm or more in more than half of each pedon;

b. Do not have, within 1 m of the soil surface, prismatic or

blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix; and
c. Have cracks that remain open more than 150 cumulative days in most years and have a mean annual soil temperature that is 15°C or higher.

Entic Chromusterts are like Typic Chromusterts except for *a*.

Paleustollic Chromusterts are like Typic Chromusterts except for *b* or for *a* and *b*.

Udic Chromusterts are like Typic Chromusterts except for *c* and have cracks that remain open from 90 to 150 cumulative days in most years.

Udorthentic Chromusterts are like Typic Chromusterts except for *a* and *c* and have cracks that remain open from 90 to 150 cumulative days in most years.

Pellusterts

Distinctions between Typic Pellusterts and other subgroups

Typic Pellusterts are the Pellusterts that
a. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon;
b. Have cracks that remain open for more than 150 cumulative days during each year and have a mean annual soil temperature that is 15°C or higher; and
c. Do not have within 1 m of the soil surface prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix.

Entic Pellusterts are like Typic Pellusterts except for *a*.

Udic Pellusterts are like Typic Pellusterts except for *b*.

Udothentic Pellusterts are like Typic Pellusterts except for *a* and *b*.

XERERTS

Key to great groups

DAA. Xererts that have a dominant chroma, moist, of 1.5 or more in the matrix of some subhorizon in the upper 30 cm in more than half of each pedon.

Chromoxererts, p. 243

DAB. Other Xererts.

Pelloxererts, p. 244

Chromoxererts

Distinctions between Typic Chromoxererts and other subgroups

Typic Chromoxererts are the Chromoxererts that
a. Do not have distinct or prominent mottles (these terms refer to contrast, not size) within 50 cm of the soil surface in more than half of each pedon;
b. Have a color value, moist, less than 3.5 and a value, dry,

less than 5.5 throughout the upper soil to a depth of 30 cm in more than half of each pedon; and

c. Do not have, within 1 m of the soil surface, prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix.

Aquic Chromoxererts are like Typic Chromoxererts except for *a.*

Entic Chromoxererts are like Typic Chromoxererts except for *b.*

Palexerollic Chromoxererts are like Typic Chromoxererts except for *c.*

Pelloxererts

Distinctions between Typic Pelloxererts and other subgroups

Typic Pelloxererts are the Pelloxererts that

a. Have in all subhorizons to a depth of 1 m a chroma, both dry and moist, less than 1.5 or, if the chroma is 1.5 or higher, there are in some subhorizon between 30 cm and 1 m distinct or prominent mottles, or concretions that are due to segregated iron or manganese; and

b. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon.

Chromic Pelloxererts are like Typic Pelloxererts except for *a.*

Entic Pelloxererts are like Typic Pelloxererts except for *b.*